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THE BOTANICAL GARDEN AT BUITENZORG, JAVA.

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PROBABLY the term 'botanical garden' brings to the minds of most people something in the style of a cemetery with a few trees and a great many oblong beds of herbaceous plants, each bed with a white label suggesting a small gravestone. In a properly appointed botanical garden most people expect to see also some hot houses for orchids and a tank with warmed water for tropical water lilies and lotus.

Should an ordinary mortal, or even a botanist, be dropped from a balloon into the middle of the garden at Buitenzorg, he would, for a time, hardly appreciate that he was in a botanical garden. The usual 'ear marks' of such an institution are certainly not apparent at first glance. The plants are mostly trees, no warm tanks are necessary, and there are cool houses instead of hot houses. The botanist, in looking at the names of trees would only now and then recognize one he had run across somewhere in a text-book. Were it not for a very few names, he might believe he had landed on some other planet. Certain it is he would see few plants he had known before in the temperate zone.

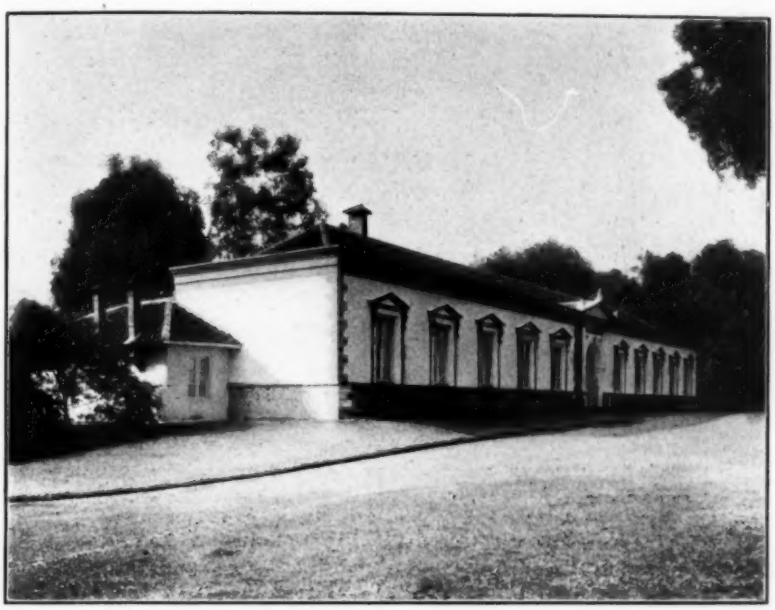
After a time spent at Buitenzorg the term 'plant' no longer suggests a small green creature with pretty flowers—something which dies down in autumn and comes up at Easter time. The plants at Buitenzorg are trees, and there are hundreds, nay, thousands, of these; while only a trifling space is allotted to puny little herbs—the things that we of the temperate regions know as 'plants.'

Of course the well informed naturalist knows the tropical world as the 'mother of life,' and he expects to see a wealth of green, a super-

A LARGE LEANA (*Entada scandens*) NEAR THE ENTRANCE OF THE BOTANICAL GARDENS.

VIEW ACROSS THE POND TO THE GOVERNOR GENERAL'S PALACE AT BUITENZORG.

abundance of plant individuals and plant species. Still I doubt if any one who has not actually visited a wet tropical region can have a very clear idea of the real luxuriance of Buitenzorg. In an ordinary temperate forest the number of species of trees can almost be counted on the fingers of two hands; the species in a northern coniferous forest might be counted on the fingers of a single hand. In a west Java forest there may easily be fifty species of trees within a distance of as many feet from an observer. In the whole island of Java there are



LABORATORY FOR RESEARCHES.

probably a thousand different kinds of arborescent plants—perhaps more.

In the botanical garden an attempt is made to assemble the various plants of the Dutch East Indies and also to get the more notable species from other lands. This garden should be especially useful at this time to American botanists who may be intending to work in the Philippines. Java belongs to the same floral region as the American East Indies, and our islands will doubtless show some likenesses and differences in flora, which will be of great interest. At Buitenzorg the visiting botanist has before him, in well organized form, an epitome of all tropical botany.

Aside from any special interest which American botanists might have in Buitenzorg, there are countless objects of general botanical interest to be seen there. One who keeps in touch with modern bot-

anical literature can not but be struck with the fact that in these days tropical botany is becoming more and more important. The ordinary text-books still illustrate most points in physiology and morphology by reference to plants of the temperate zone, yet there is an increasing tendency to refer more often to tropical plants. The modern botanist needs to know something of the tropics—the more the better. At Buitenzorg he can learn a great deal in a short time.

The visitor, on going through the gate of the garden, enters at once a long avenue planted with canary trees (*Canarium commune*). Here is something with no counterpart anywhere else in the world. As one walks down Canary Avenue in early morning he notices perhaps, first the darkness, then looking up he sees the branches above, over-arched, as it were, to form the vaulted roof of a Gothic cathedral. Here and there a few stray sunbeams, stealing through, make bright patches of light on the moist roadway; the lianas, climbing up the great tree trunks, are covered with dew and their huge leaves glisten as they are gently waved by the morning breeze. Their long, aerial roots sway to and fro as slow-moving pendulums. The great buttressed

A Path in the Jungle.

JUNGLE SCENE. A SPECIES OF PANDAMUS WITH LONG GRASS-LIKE LEAVES.

A PLANT (ZLATOSTENIMA) WITH LONG POINTED DRIP-TIPS.

roots of the canary trees, covered with epiphytic ferns and orchids, seem almost too picturesque to be quite natural. Everywhere the eye feasts on a wealth of green. It is hard to escape the thought that this is fairy land.

When the visitor passes onward to the lake and looks across at the wooded island where are planted magnificent flowering trees, shrubs of wonderful foliage, and, more striking than all else, the red stemmed 'sealing wax palm'—when he looks across the lotus and *Victoria regia* to all this tropical luxuriance he must perforce become enthusiastic, even though he be by nature the most cold-blooded of men.

The garden has an extent of about one hundred and fifty acres. Through one end of it passes the Tjilwong River and along here is some low ground, while further back is higher land with more undulating surface, where, from certain vantage points, good views may be had of the neighboring mountains. Only a few avenues are open to carriages, but there are many neatly paved foot-paths usually following a somewhat winding course. These foot-paths form the boundaries of the different sections in which are trees of the various plant families arranged in systematic and orderly fashion. To a botanist, interested in a given group of plants, this is a most useful arrangement. It is much better than the more common plan of grouping trees according to the kind of soil in which they do best, and still better than the even more usual plan of scattering them about, hit or miss, wherever there happens to be room.

A visitor to the garden who is not a botanist will be disappointed that the labels give only the scientific names of trees. He who may

wish to see teak, satin-wood, ebony, the mango, nutmeg, rambutan and other notable trees must first find out for each the two many-syllabled Latin words which are used to designate a plant for scientific purposes. As these words are painted on the labels in a sort of modified German script they are not quickly read. Besides this the labels are narrow and frequently the name will not go in one line, but must be divided. The division is often made, not with regard to the nature of the word, but to the convenience of the native who does the painting. So one may see such divisions as 'flavesce-ns,' 'co-mmune,' 'macrant-hum,' 'integrif-olia,' and some others quite as startling.

If there were signs up showing the families in a given lot, and if the labels gave the common names and native home of some of the more important trees, even the professional botanist would be pleased; to the ordinary visitor there would be added an interest now quite lacking. The guide books give a bad English translation, from the Dutch, of directions for seeing the garden. No one, however, unless gifted with second sight, could even keep to the course mapped out, let alone see the various objects mentioned. During my stay in Buitenzorg I used to get out the guide book most religiously every Sunday. But although I spent some hours every week day in systematic study of the gardens, I was never able to follow with ease the official itinerary.

But even if the guide book be maddening, one can find many interesting things without great trouble. The Canary Avenue is something which never palls. The fine collection of palms is a joy to look upon. There are all sorts of queer-looking and strange plants to attract attention. Screw pines with their curious prop roots interest every one and cycads and tree ferns deserve more than a passing glance.

One is sure to be impressed with the great number of trees bearing conspicuous flowers. More than one man has asked me, on finding me to be a botanist, whether our northern trees would blossom out handsomely if grown in the tropics. Of course I have to say 'no'; that a leopard would more easily change his spots. It so happens that trees with large, showy flowers are more common in the tropics than in our part of the world. But we have the catalpa and tulip tree. There are plenty of trees in the tropics with inconspicuous flowers, too, but these the non-botanist does not notice.

The climate of Buitenzorg is very moist, there being a yearly rainfall of two hundred inches, or about six times that of New York. Dry spells seldom last long and the atmosphere is nearly saturated with moisture at all times. Correlated with the wet climate we find that many trees have leaves with long pointed drip-tips. The water from the surface of the leaf collects on these pointed tips and runs off quickly. Trees do not need a thick covering of cork to protect them from drying out or to save them from cold. So we find, instead of the

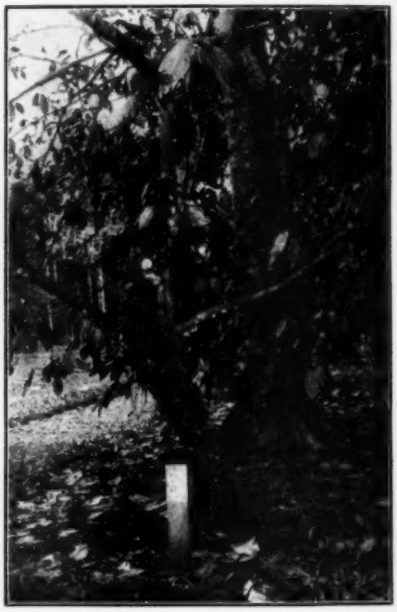
CANARY AVENUE AT BUITENZORG

THE SAUSAGE TREE.

thick, rough, furrowed bark of our own forests, only smooth trunks even in the case of large and old trees. This often leads strangers to underestimate the size of tropical trees, for they have come to think of smooth bark as belonging only to small trees.

The limp, dangling leaves of some tropical trees are most curious. They are frequently quite red, just as are the young leaves of maples in temperate climates. It is not easy to say just why some plants have adopted this peculiar habit of letting the leaves grow full size before they are strong enough to stand out in proper fashion. Certain it is, however, that by hanging down in this way the young, tender leaves are much less exposed, and hence in less danger of injury by excessive light and heat.

A moist climate, such as that of Buitenzorg, favors the growth of epiphytic or perched plants—also of parasites. Seeds or spores, carried by the wind or birds, find lodgment in the forks of trees. With plenty of moisture in the air and a constant warm temperature they grow luxuriantly. Thus it happens that trees are covered with moss. Even the very leaves are often marked with delicate patterns of moss and lichen. Orchids and ferns in great number are perched upon the horizontal branches and the smooth trunks also serve for the lodgment of many plants as well. Since Darwin's time every one has known something about orchids: plants with curious flowers adapted



CHOCOLATE TREE, SHOWING CAULANTHY.

to insect visits—flowers of handsome colors and strange shapes. But many orchids have small greenish or white flowers, and these are the ones most common in the Buitenzorg garden. There is also a good collection of species which have been 'planted,' not planted in the ground, but simply tied to tree trunks. Here they get along very well without drawing any water from the soil. There is plenty of moisture in the air and these plants are provided with absorbing tissues to take in what they need.

Things grow on a large scale in the tropics. Many of our tiny herbs at home have tropical relatives which are large trees. There

INDIA RUBBER TREE.

are tree ferns, the tree-daisy and the tree-tomato. In our own part of the world the sunflower is the largest plant of the composite family, but in the tropics there are many shrubs and trees belonging to this order of plants. Fruits of great size are common. A good example is seen in the 'sausage tree,' the fruits of which are great sausage-shaped structures two feet long, weighing many pounds. The jak tree has a fruit which looks something like an enormous watermelon, except for the roughened warty outer rind. The flowers, and hence the fruit, are on old wood—not developed at the tips of young branches as are the apples, peaches and other fruits familiar to us. Such production of flowers and fruits on the older parts of the tree is known as 'cauli-

florie' or 'caulanthy,' the terms meaning 'flower on the stem.' Caulanthy may often be seen in the tropics, while among trees of temperate regions it is almost unknown.

Plants inhabited by ants are sure to strike the attention of visitors. There are many of these so-called 'myrmecophilous' plants in the garden at Buitenzorg; some brought in from the neighborhood, while others, behaving like Topsy, 'just growed.' The commonest are species of *Myrmecodia,* woody plants about two feet tall, with the base of the stem much swollen and containing large winding passages swarming with ants. These plants do not grow on the ground, but are at-

WARINGIN TREE, BATAVIA.

tached to the branch of some tree, a habit of life very common in moist climates. A handsome tree known as *Humboldtia* is also myrmecophilous. The flowering twigs are swollen and hollow—the cavity opening to the outer world by a small hole through which ants enter. Apparently in these various cases the ants do not serve the plants in any way. There are, however, certain species of *Acacia,* which produce a sweet substance attractive to a certain kind of warlike ants, and these ants protect the tree from the attacks of the leaf-cutting ants. Other kinds of *Acacia,* not provided with ant police, are often seriously damaged by the leaf-cutters.

In our school geographies we have all read about the wonderful banyan tree which sends down roots from its outspread branches and

eventually covers a great area. A whole avenue of such trees is to be seen at Buitenzorg. The trees are the 'waringen,' a sort of banyan, and the avenue is called the 'Waringen Alle.' Other trees, such as the India rubber plant, have the same habit of putting forth aerial roots which grow down and penetrate the soil and eventually cause a wide spreading of the tree.

A short magazine article can not bring the reader very close to tropical plant life as shown in the Buitenzorg garden, but the illustrations may help to make clear some of the features I have mentioned. It must be understood that the gardens are maintained primarily for scientific purposes and that there are countless objects, interesting to the botanist, the enumeration of which would be wearisome to the general reader.

It is the wish of the director of the gardens that botanists from all countries should make use of the garden for study. At his suggestion the government erected some years ago a commodious laboratory for the exclusive use of visiting men of science. Naturally enough, since Java is a Dutch dependency, most of the visitors thus far have come from Holland, but many Germans have also been there. Almost no Americans have studied in Buitenzorg. This is the more strange, since our botanists are accustomed to travel long distances and many have worked in Europe. With the increased importance of the tropics which has come in recent years, there should be a greater interest developed in the study of tropical life. It is much to be desired that our own botanists make use of this and other tropical gardens in order that we may not remain behind other nations in this important branch of natural science.

MARKET PLACE IN BUITENZORG.

HYPNOTISM, ITS HISTORY, NATURE AND USE.

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IT is perhaps unnecessary to state that the word hypnotism brings to the mind of the average person timid recollections of many criminal acts. That is because few people hear of hypnotism in its proper sphere. It is clothed with the garb of shame; it is surrounded with all the horror belonging to the age of witchcraft. Newspapers delight in depicting its bad sides, in painting to the world the crimes that have been committed under its influence, the fearful results of its all powerful spell. To most it means a giving up of one's will to another who is superior, the crushing of one's entity by the power of another, the total abstinence of individual self-control, the entire weakening of one's higher intelligence. Vivid imagination supplies the result—suffering, hardship, labor and total subservience.

The question arises, 'Why should hypnotism have been thus derided?' Simply and plainly because the ignorance of people in general has given it no opportunity to show its good sides. Unfortunately people are always looking for the 'eternal gullible' and are not satisfied until they get a taste of it. And as hypnotism was first practised solely and is now practised mostly by men who have made the world their dupes, the world has had to suffer in the advancement of hypnotism on a scientific basis. But it has been so with other sciences. Astrology and alchemy are now things of the past; but astronomy and chemistry are their results—two great and everlasting sciences. There is therefore still great hope for hypnotism; for, although known under different names for so many hundreds of years, it is still in its infancy and the scientific aspect of the subject is yet in embryo.

Before, however, proceeding to cases in point, we may review briefly the history of hypnotism up to the present day. Call it what we may, since the beginning of the world, before Noah ever went on the Ark or the whale swallowed Jonah (much to the discomfort of both), hypnotism has been practised. The influence of one man over another by a certain innate quality or by personal magnetism has always been. Even Eve exerted an influence over Adam which has precipitated the world into misery and kept it there ever since. As time went on, people recognized this influence, gave it a name and called it the influence of the gods, the result being that those who were ordained

with this wonderful power were called God's ministers. Soothsayers, divine healers, the oracle ministers, all made the oriental people construe this power by religious means. Among the Chaldeans, Babylonians, Persians, Hindoos and other ancient peoples, there were priests who, because of their power of exerting a superhuman influence over others, were considered divine. To this day the vogis and fakirs of India use this power and throw themselves into a state of hypnotic ecstacy and revery. In the eleventh century it was used in the Greek church, as it is now by the omphalopsychics. In the middle ages it was practised by Paracelsus, who maintained that the human body possessed a double magnetism, the first magnetism coming from the planets, the second from flesh and blood. All through the middle ages, hypnotism was practised under different names such as witchcraft, divinations, etc. It was supposed to be a supernatural power derived from Satan himself, and, therefore, the user of this power was expelled from society and sometimes put to death. Magic spells where people went into trances or out of their head were of common occurrence. Religious ecstasy, demon-possession, cures by shrines and relics, the cure by the king's touch, etc., were all phenomena of this same sort.

During the seventeenth century, a number of faith-healers sprang up all over the continent and British Isles. Many of these men were noted for their skill, but the one who attained the greatest reputation was one by the name of Greatrakes, who was born in Ireland about 1628. This 'healer' was sent for by a Lord Conway who expressed his message in the following language: "to cure that excellent lady of his, the pains of whose head, as great and unparalleled as they are, have not made her more known or admired abroad than have her other endowments." At Lady Conway's was a miscellaneous gathering, chiefly engaged in mystical pursuits, 'an unofficial but active society for psychical research, as that study existed in the seventeenth century.' Says Mr. Lang: Greatrakes' special genius in these mystical pursuits was of divine agency; for he tells us that at one time "he heard a voyce within him (audible to none else), encouraging to the tryals: and afterwards to correct his unbelief the voice aforesaid added this sign, that *his right hand should be dead, and that the stroaking of his left arm should recover it again,* the events whereof were fully verified by him three nights together by a successive infirmity and cure of his arm." We are told that he failed to cure the lady's malady but that he worked some wonderful miracles of healing among the sick of the neighborhood.

Henry Stubbe, a physician of Stratford-on-Avon, thus comments on Greatrakes' miracles. He says "that God had bestowed upon Mr. Greatrakes a peculiar temperament, etc., composed his body of some particular ferments, the effluvia whereof, being sometimes introduced

by a light, sometimes by a violent friction, should restore the temperament of the debilitated parts, reinvigorate the blood and dissipate all heterogeneous ferments out of the bodies of the diseased, by the eyes, nose, mouth, hands and feet." Indeed, he recognized the difference between functional and organic complaints; and he only meddled with such diseases as 'have their essence either in the masse of blood and spirit (or nervous liquors) or the particular temperament of the part of the body' and attempted to cure no disease 'wherein there is a decay of nature.' "This is a confessed truth by him, he refusing still to touch the eyes of such as their sight has quite perished." None the less his cures were regarded as miraculous, and Dr. Stubbe tells us that 'as there is but one Mr. Greatrakes, so there is but one Sonne'; Greatrakes' method consisted principally in *stroaking* and *passings* and in driving the pains from one point to another until they went out at the fingers or toes.

In the latter half of the eighteenth century many fakirs, alleged philosophers, quacks and cosmongerers came to the front. Swedenborg, with his inspirations; Cagliostro, with his idea of personal power; Schrepfer, with the beginning of spiritualism; and then Gassner, the priest healer, who gave to Mesmer later on some of the ideas for the foundation of his theories.

Johann Joseph Gassner, a Swabian priest, appeared upon the scene in 1773. He was a forerunner of our modern spiritualist in a way, but had the added distinction of attributing all diseases to the devil. So his object was to pray for the expulsion of this satanic being. The patient had to have implicit faith and was made to give a detailed account of his malady. Gassner's next procedure was to chant various symptoms such as pain, weakness, stiffness, etc., and at his peremptory command to 'stop,' these symptoms would disappear and the patient be well again. At the words 'You will cease being disabled,' the patient's symptoms vanished. 'Your right hand and arm will become somewhat weak,' he says; and no sooner are the words out his mouth than the right hand is cold and numb and the pulse is accelerated. 'Your left hand will become as your right one was and this one will be normal,' is his next invocation, whereupon the left hand is cold and numb and the right returns to normal. Gassner keeps up these incantations until the patient is entirely cured, each prayer being accompanied by the invocation that 'this is accomplished in the name of the Lord, Our Father.' Gassner's cures in theory and practise were identical with those of Greatrakes, except that the mystery was now clothed in a religious garb. In both, the predominant idea was the suggestion to the patient that he would get well.

The reason why hypnotism was not studied scientifically until the middle of the eighteenth century was that there was too much of an air of mystery surrounding the workings of the phenomena. Whenever

hypnotic power was discovered in a person, he at once considered himself as one who possessed attributes which placed him above the plane of society. Suggestion was of course practised as it always has been, but the true idea of what the power consisted of was unknown. At last, toward the close of the century, Frederick Anton Mesmer rose before the world as a disciple of a new force which was destined to turn the scale on to the side of science and forever after to present hypnotism in a new light.

Frederick Anton Mesmer was born at Weil, near the point at which the Rhine leaves the Lake of Constance, on May 23, 1733. He studied medicine at Vienna under eminent masters, although at first his parents had destined him for the church. Interested in astrology, he imagined that the stars exerted an influence on beings living on the earth. He identified the supposed force first with electricity and then with magnetism; and it was but a short step to suppose that stroking diseased bodies with magnets might effect a cure. In 1776, meeting Gassner in Switzerland, he observed that the priest effected cures without the use of magnets, but by manipulation alone. This led Mesmer to discard the magnets, and to suppose that some kind of occult force resided in himself by which he could influence others. Mesmer's first practical work with magnets was in 1779, when he magnetized a young lady complaining of various functional disorders. This emotional young lady 'felt internally a painful streaming of a very fine substance, now here, now there, but finally settling in the lower part of her body and freeing her from all further attacks for six hours.' She was extremely sensitive to any of Mesmer's suggestions, but would obey no one but him. Thus we see the primeval workings of animal magnetism, afterwards called hypnotism.

Mesmer removed to Paris in 1778, and in a short time the French capital was thrown into a state of great excitement by the marvelous effects of what he called mesmerism. Mesmer soon made many converts; controversies arose; he excited the indignation of the medical faculty of Paris, who stigmatized him as a charlatan; still the people crowded to him.

While at Paris his practise became so enormous that it was impossible for him to handle all his patients. So he invented a scheme by which a number of his patients could be magnetized at once. He had troughs filled with bottles of water and iron filings, around which the patients stood holding iron rods which issued from the troughs. All the subjects were tied to each other by cords so that they could not break away and thus spoil the contact. Perfect silence was necessary and soft music was heard. The patients were affected variously, according to the suggestion Mesmer gave them. Some became hysterical, others crazed, some became affectionate and embraced

each other, while others laughed and became repulsive. This lasted for hours and was followed by states of dreaminess and languor. A picture given by Binet and Feret, two eminent French scientists, will present an idea of these meetings.

Mesmer, wearing a coat of lilac silk, walked up and down amid this agitated throng accompanied by Deslon and his associates whom he chose for their youth and comeliness. Mesmer carried a long iron wand, with which he touched the bodies of the patients and especially the diseased parts. Often laying aside the wand, he magnetized the patients with his eyes, fixing his gaze on theirs, or applying his hand to the hypochondriac region and to the abdomen. This application was often applied for hours, and at other times the master made use of passes. He began by placing himself 'en rapport' with his subject. Seated opposite to him, foot against foot, knee against knee, Mesmer laid his fingers on the hypochondriac region and moved them to and fro, lightly touching the ribs. Magnetism with strong electric currents was substituted for these manipulations when more energetic results were to be produced. The master, raising his fingers in a pyramidal form, passed his hands all over the patient's body, beginning with the head, and going downward over the shoulders to the feet. He then returned to the head, both back and front, to the belly and the back and renewed the process again and again until the magnetised person was saturated with the healing fluid and transported with pain or pleasure, both sensations being equally salutary. Young women were so much gratified by the crisis that they wished to be thrown into it anew. They followed Mesmer through the halls and confessed that it was impossible not to be warmly attached to the person of the magnetizer.

Mesmer was not an impostor by any means. He had deceived himself and had thus deceived others. But the Academy of Sciences in Paris believed that he was a mystic and a fanatic, and made it so hot for him that he was finally forced to leave France, where, however, he returned later. He died in 1815, and for a time animal magnetism fell into disrepute and Mesmer was denounced as an impostor.

Before Mesmer's death, he moved from Paris to a secluded spot among the hills. We see him at the last—bitterly complaining of the treatment he had received, thoroughly convinced as to the truth of his pet theories, performing various cures for the peasants about him, and living the simple life of a hermit.

Throughout Mesmer's career, the streets were not paved with gold. Many people died under his treatment, giving the belief that the treatment itself was the cause of death. He was treated with ridicule wherever he went. Papers, plays, etc., brought him even more prominently before the public in a more ridiculous light than his own hypothetical and mystical performances. A comedy, 'Docteur Modernes' brought his procedures on the stage. It severely criticized his 'fanatical' enthusiasm for a quondam science and portrayed the supposed abuses of his treatment. In England notices like the following appeared in the leading journals:

The Wonderful Magnetical Elixir. Take of the chemical oil of Fear, Dread and Terror, each 4 oz.; of the Rectified Spirits of Imagination, 2 lbs. Put all

these ingredients into a bottle of fancy, digest for several days, and take forty drops at about nine in the morning, or a few minutes before you receive a portion of the magnetic Effluvia. They will make the effluvia have a surprising effect, etc., etc.

Once, in 1785, a mock funeral oration upon Mesmer took place, making his exhibitions and theories seem more ridiculous than ever. Thus he was tossed about between ridicule and praise until, as we have seen, his life was hardly one of harmony or joy.

Braid.

Although a number of men followed Mesmer, appropriating his method, enlarging upon it and changing it somewhat—such men as de Puysegur—it will be impossible in such a brief essay to tell of all of them. However, there is one man who rose up in the chaos of the times and again added new facts and theories to the science. This man was Braid, a surgeon of Manchester, England. Braid was born in the year 1795 on his father's estate in Fifeshire. He received his education at the University of Edinburgh, later being apprenticed to Dr. Chas. Anderson, of Leith. After graduating, he was appointed surgeon to the Hopetown mining works in Lanarkshire, later moving to Dumfries, where he engaged in practise with a Dr. Maxwell. An accident happening at that time brought to his town a Mr. Petty, who finally persuaded him to move to Manchester. It was here that he carefully worked on his new discovery and practised his cures. He died on March 25, 1860.

There is very little in Braid's life of especial interest, except his investigations in animal magnetism. His life seems to have been particularly free from the early struggles of a young practitioner. His interest in animal magnetism dates from the time he witnessed a séance by a M. Lafontaine, a traveling mesmerist. He was extremely skeptical, but this one urged him to try experimenting himself.

In 1866 this M. Ch. Lafontaine, a traveling mesmerist, published his 'Memoirs of a Magnetizer.' If it had not been for this, the electro-biologists of America, under one named Grimes, might have claimed prior right to the discovery of hypnotism. M. Lafontaine thus describes the state of affairs at that time.

Having accomplished the cure of numerous deaf and blind persons, says he with modest assurance, as also numerous epileptic and paralytic sufferers at the hospital (this was in Birmingham), I repaired to Liverpool, but only to meet with disappointment; few persons attended the séance; and on the following day I proceeded to Manchester in which city my success was conspicuous. The newspapers reported my experiments at great length, and to give some idea of the sensation I created, I may say that my séances returned me a gross total of 30,000 frances. I put to sleep a number of persons who were well-known residents of Manchester. I caused deaf mutes to hear, operated a number of brilliant cures. After my departure, Dr. Braid, a surgeon in Manchester, delivered a lecture in which he proposed to prove that magnetism was non-existent. *From this lecture Braidism, afterwards called*

hypnotism, originated, ardent discussions arising, even from the beginning over this pretended discovery. I received letters from Manchester entreating me to return, and I did so on a date when Dr. Braid had announced a demonstration. His experiments were given but unfortunately, on this occasion none of them succeeded; neither sleep nor catalepsy was obtained, and every moment I was appealed to. In the facts that were advanced on this occasion by Dr. Braid, there was in my opinion, absolutely nothing that was remarkable, and had not that gentleman been honorably known in the town, I should have supposed that he was mystifying his audience. The next day, and for six days consecutively, I experimented after his own fashion on fifty or sixty subjects and the results were practically *nil.* I then gave a magnetic séance and the results on Eugene and Mary were marked and positive.

The value of the quotation rests solely on the opportune remark that Braid was the first to apply the name hypnotism to animal magnetism. One should not forget that Eugene and Mary were two subjects whom Lafontaine carried with him from town to town and on whom he could rely for phenomena.

Though Braid survived his discovery by not more than eighteen years, he lived to know that it was well on the road to acceptance by the competent opinion of the time. In the latter part of his life he said, "I feel no great anxiety for the fate of hypnotism, provided it only has 'a fair field and no favour.' I am content to bide my time, in the firm conviction that truth for which alone I most earnestly strive, with the discovery of the safest, and surest, and speediest modes of relieving human suffering, will ultimately triumph over error" ('Magic, Witch,' p. 53).

The enemies of Braid were as vociferous in their denunciation of him as his friends were earnest in their praise. And what may seem the greatest surprise and yet what seems to be a natural consequence of opposition, the Mesmerists themselves were the ones who were the loudest in opposing him. However, his method has stood the test of years and still prevails among those who practise the art now-a-days.

As was said before, the first exhibition that Braid ever attended was one given by this same Lafontaine. One fact, *the inability of the patient to open his eyelids,* arrested his attention. He considered this a real phenomenon and was anxious to discover the physiological cause of it.

In two days afterward, he says, I developed my views to my friend Captain Brown, as I had previously done to four other friends; and in his presence and that of my family and another friend, the same evening, I instituted a series of experiments to prove the correctness of my theory—namely that the continued fixed stare, by paralyzing nervous centers in the eyes and their appendages and destroying the equilibrium of the nervous system, thus proved the phenomenon referred to. The experiments were varied so as to convince all present, that they fully bore out the correctness of my theoretical views. My first object was to prove, that the inability of the patient to open his eyes was caused by paralyzing the upper muscles of the eyes, through their continued action during the protracted fixed stare, and thus rendering it

physically **impossible for him to open them. With the view of proving this, I requested Mr. Walker, a young gentleman present, to sit down, and maintain a fixed stare at the top of a wine bottle, placed so much above him as to produce a considerable strain on the eyes and eyelids, to enable him to maintain a steady view of the object. In three minutes his eyelids closed, a gush of tears ran down his cheeks, his head drooped, his face was slightly convulsed, he gave a groan and instantly fell into a profound sleep, the respiration becoming slow, deep and sibilant, the right hand and arm being agitated by slight convulsive movements. At the end of four minutes, I considered it necessary, for his safety, to put an end to the experiment.**

Braid became so convinced that his interpretation of the phenomena was the correct one that he used it universally, succeeding in a remarkable number of cases. His method was as follows:

He would take any bright object, most often his lancet case, and holding it about fifteen inches from the eyes and in such a position as to strain them and still allow the patient to gaze steadily at it, he would carry it slowly toward them until the eyelids closed involuntarily. After a preliminary contraction of the pupils, they would dilate, and finally a tremulous motion of the iris would take place. If this did not succeed after a few minutes, he would try again, letting the patient understand that his eyes and mind had to be riveted on the one idea of the object before him. The primary fact was the fixation of the mind on a certain object. Nay, even the hynotist himself, if he use the method of attraction, may be hypnotized, as Braid shows in the following example. Mr. Walker, Braid's friend, offered to hypnotize a certain person. When Braid went into the room where the experiment was going on, he saw the gentleman sitting staring at Mr. Walker's finger. Mr. Walker was standing a little to the right of his patient with his eyes fixed steadily on those of the latter. Braid passed on, and when he returned he found Mr. Walker standing in the same position fast asleep, his arm and finger perfectly rigid and the patient wide awake, staring at the finger all the while.

After Braid, many men pursued the scientific investigation of the phenomena. The interest in the new science since 1875 has spread quickly over Europe. In Belgium, the eminent psychologist Delboeuf of Liège, made a path for it. In Holland such men as Van Reuterghem, VanEiden and De Jong used hypnotism for curative purposes; in Denmark, Norway and Sweden, there were Johannessen, Sell, Frankel, Calsen and Wetterstrand, of Stockholm, and finally Swedenborg. In Russia were Strembo and Tokarski; in Greece, Italy and Spain, hypnotism has greatly come into play in medical treatment. In England, Carpenter, Laydock, Sir James Simpson, Lloyd-Tuckey, Mayo and others have used it for curing the sick. In America, the science also has its advocates. It is one of the subjects constantly appearing before the Society for Psychical Re-

search. In South America, it numbers among its adherents, David Benavente and Octavio Maria, of Chili. The interest in hypnotism in France centered around two schools, the school of Salpêtrière and the school of Nancy. The former was led by Charcot, whose luminous researches in this subject are epoch-making.

The Paris school held that hypnotism is the result of an abnormal or diseased condition of the nervous system; that suggestion is not at all necessary to produce the phenomena; that hysterical subjects are the most easily influenced; and that the whole subject is explainable on the basis of cerebral anatomy and physiology. But lately the followers of Charcot, who had been numerous in the beginning because he was so highly reliable a man, have begun to dwindle away and have turned to the school of Nancy. The reason for this is obvious to any one who has studied hypnotic phenomena. The first objection to the school of Salpêtrière is that most of the experiments have been made on hysterical women. In the second place, this school ignores suggestion, which has been found to be one of the most important factors in hypnotism. They appreciate of course that it can be used, but assert that it is not necessary.

The school of Nancy, led by Bernheim, met with equal success and is now upheld by more people than the other school. The theory of the school of Nancy may be summed up in a few words: first, the different psychological conditions in the hypnotic state are determined by mental action; secondly, people of good sound physical health and of perfect mental balance can produce the best results; and thirdly, all the mental and physical actions are the result of suggestion. In fact suggestion is the all important factor in producing the various phenomena.

Liebault, and Bernheim, his pupil, by bringing forth the idea of suggestion, have made themselves in a way the equal of Braid, for in continuation of the latter's method, the method of the former is always used now-a-days. The influence of Bernheim over his patients is remarkable. His great success may be accounted for by the confidence his patients have in him. Of course the low intellectual state of the peasant class of France may have something to do with it, for one can hardly think that in any ordinary community this supreme belief and trust in a human being could exist. To Nancy people come from all over the provinces to visit this 'Man of God,' who performs experiments and cures which seem divine. Bernheim goes from one patient to another, shouting 'sleep.' Many of them having been hypnotized by him often fall into the state immediately. When the experiments are over he goes the rounds of his patients, snapping his fingers, in which way he awakens them.

To sum up then, we may say the history of hypnotism may be divided into five epochs. The first before the time of Mesmer; the

second, the age of Mesmerism, when personal magnetism was supposed to be the attractive power; the third, the age of Braid, when the science was put on a physiological basis; the fourth, the age of Bernheim and Charcot, when the idea of suggestion was brought to the front and hypnotism was used indiscriminately; and lastly, the fifth, the age we are in now, where the tendency is to restrict hypnotism and to classify it for specific uses.

The Nature of Hypnotism.

Each individual has a separate state of consciousness which changes as do the thoughts therein. It is in the waking state that we have separate individualities. Now let us see the gradations of this consciousness. At this present moment we shall say we are listening intently to a sermon. That is the thing uppermost in our minds, and as long as our minds are upon it we are exercising acute consciousness. But, even if our attention to this sermon is the central thing, in the fringe of our mental picture a number of other thoughts are jumping around, any one of which may be powerful enough to force its way into the middle of the picture and to usurp its place. For example, all the while we are listening to this sermon we are more or less conscious that the seats we are in are hard, that somebody is talking next to us, etc. Our seats may become so uncomfortable that it may occupy our whole attention, or something outside may seem of more interest. If our attention jumps from one thing to another, it is called diffused consciousness. The next step to diffused consciousness is the dreamy state where the mind is half way between waking and sleep. Anything may come into the mind while in this state and be the predominant idea, to be chased out again by a next idea. It is for this reason that dreams usually present such a chaos and jumble. Our thoughts tumble over one another to get from the fringe of consciousness to the foreground. Any external sensation will be greatly exaggerated and may turn the trend of our thought. A warm bed might feel like the fire of hell, a heavy dinner with indigestion like the battles of heroes using our poor bodies as the fighting ground. As dreams gradually fade away we approach our first hypnosis or sleep, which, in the beginning, is slight, but gradually deepens, finally consciousness being entirely lost.

Thus we have traced the process of natural sleep to which hypnotic sleep is closely akin. The person at first has a diffused attention, he then confines his attention to sleep, he next passes into a dreaming state, then into a light sleep and lastly into a deep sleep.

The differences between it and natural sleep are as follows: first, the state ordinarily is produced by another; secondly, the person must have faith; and thirdly, the phenomena in the sleep must be produced by suggestion. The two latter were fully recognized years ago and

have formed the basis of all psychical cures ever since. How the sleep can be produced by another was seen in the experiments of Braid, where one appreciates fully that the person really hypnotizes himself by gazing at an object. The full understanding between hypnotized and hypnotist has never been really understood, and so here we are stopped short.

The theory of Dr. Hudson may put us on the right track. Because it is so convenient a theory and tends to make plausible a number of things which otherwise could not be understood, I am going to take the liberty of detailing it here. Dr. Hudson claims that every normal person is possessed of two minds, a subjective one and an objective one. The objective mind is the one we use every day, a mind fully capable of forgetting and the only one of which we are ordinarily cognizant. The subjective mind is the *perfect* mind wherein are stored up all the numerous thoughts that have ever come into it, there lying dormant, only to be reawakened when a new set of associations brings them forth.

It is this mind which we may say is used in hypnotism, in somnambulism, the one which shows itself in altered personality and in various other abnormalities. Some authors consider this the subliminal or subconsious mind.*

That there is another mind far more perfect and which brings to our recollection many things forgotten, seems to be an undisputed fact. When a drug like Cannabis Indica is used or when a person is drowning, there come before his mind's eye, in a single moment, the doings of years. And so in some recorded cases of trance states the same thing is proved. A highly interesting case is given by Mr. Coleridge in his 'Biographica Literaria.'

Mr. Coleridge says:

> It occurred in a Roman Catholic town in Germany, a year or two before my arrival at Göttingen, and had not then ceased to be a frequent subject of conversation. A young woman of four or five and twenty, who could neither read nor write, was seized with a nervous fever, during which, according to the asseverations of all the priests and monks of the neighborhood, she became possessed and as it appeared, by a very learned devil. She continued incessantly talking Latin, Greek and Hebrew, in very pompous tones, and with a most distinct enunciation. This possession was rendered more probable by the known fact that she was, or had been, a heretic. The case had attracted the particular attention of a young physician, and by his statement, many eminent physiologists and psychologists visited the town and cross-examined the case on the spot. Sheets full of her ravings were taken down from her own mouth and were found to consist of sentences, coherent and intelligible each for itself, but with little or no connection with each other. Of the Hebrew, a small portion only could be traced to the Bible; the remainder seemed to be in Rabbinical dialect.

* One can not help realizing that this theory will never be fully accepted. Most psychologists are still quarreling over concepts, and no two will agree as to what is meant by a subjective or an objective mind.

All trick or conspiracy was out of the question. Not only had the young woman been a harmless simple creature, but she was evidently under a nervous fever. In the town in which she had been resident for many years as a servant in different families, no solution presented itself. The young physician, however, determined to trace her past life, step by step; for the patient herself was incapable of returning a rational answer. He at length succeeded in discovering the place where her parents had lived, travelled thither, found them both dead, but an uncle surviving, and from him learned that the patient had been charitably taken by an old Protestant pastor at nine years old, and had remained with him some years, even till the old man's death. Of this pastor the uncle knew nothing, but that he was a very good man. With great difficulty and after much search, our young medical philosopher discovered a niece of the pastor's who had lived with him as housekeeper and had inherited his effects. She remembered the girl; related that her venerable uncle had been too indulgent, and could not hear the girl scolded; that she was willing to have kept her, but that, after her parent's death, the girl herself refused to stay. Anxious inquiries were then, of course, made concerning the pastor's habits; and the solution of the phenomenon was soon obtained. For it appeared that it had been the old man's custom for years to walk up and down a passage of his house into which the kitchen door opened, and to read to himself, with a loud voice, out of his favorite books. A considerable number of these were still in the niece's possession. She added that he was a very learned man and a great Hebraist. Among the books was found a collection of Rabbinical writings, together with several of the Greek and Latin fathers; and the physician succeeded in identifying so many passages with those taken down at the young woman's bedside that no doubt could remain in any rational mind concerning the true origin of the impression made on her nervous system.

The same power of the subjective mind is many times seen in hypnotic phenomena. The case cited is but one of a number, all of which are just as wonderful. Being a mind so perfectly endowed, it is hardly too audacious to say that this mind exercises its influence over all bodily functions, so that any function may be inhibited or accelerated by its influence. For example, the following is related of Henry Clay.

On one occasion he was unexpectedly called upon to answer an opponent who addressed the Senate on a question in which Clay was deeply interested. The latter felt too ill to reply at length. It seemed imperative, however, that he should say something; and he exacted a promise from a friend, who sat behind him, that he would stop him at the end of ten minutes. Accordingly, at the expiration of the prescribed time the friend gently pulled the skirts of Mr. Clay's coat. No attention was paid to the hint, and after a brief time it was repeated a little more imperatively. Still Clay paid no attention and it was again repeated. Then a pin was brought into requisition; but Clay was by that time thoroughly aroused, and was pouring forth a torrent of eloquence. The pin was inserted deeper and deeper into the orator's leg without eliciting any response, until his friend gave up in despair. Finally Mr. Clay happened to glance at the clock and saw that he had been speaking two hours; whereupon he fell into his friend's arms, completely overcome by exhaustion, upbraiding his friend severely for not stopping him at the prescribed time.

The fact that Mr. Clay, on that occasion, made one of the ablest speeches of his life, two hours in length, at a time when he felt almost too ill to rise to his feet, and that his body was at the time in a condition of perfect anæsthesia, is a splended illustration of the synchronous action of the two minds, and also of the perfect control exercised by the subjective mind over the functions and sensations of the body ('Law of Psychic Phenomena').

I now propose to attempt to explain some of the phenomena of hypnotism by reviewing thoroughly a specific example.

On November 23, 1901, I was asked by a young lady to try to cure her of biting her finger nails. She was then about 18 years of age. I immediately replied that I should be glad to do so if I had her full permission. Besides her and myself, there were four or five other persons in the room, including her father and mother. Getting her perfectly composed, I placed my hand on the top of her head, and told her to turn her eyes in the direction of the hand. This tired her eyes very readily. They became heavier, the eyelids twitched and inside of five minutes they fell and she was sound asleep. I first placed her in a cataleptic condition. I told her her arm was a piece of stone and therefore could not be bent. Two or three of those assembled tried to bend it, but failed. Then by more suggestions I placed her in an anesthetic condition and rubbed the ball of her eye. She neither winked nor flinched. I then gave her a few post-hypnotic suggestions. For example, I told her that when she awakened she would go over and close the window, that she would then thank me for what I had done, and would feel no bad effects and also would remember nothing. Then I told her that the following Sunday I would come over, and, as soon as I told her to go to sleep, she would do so. When she awoke, she went over and closed the window, and then thanked me for what I had done. She remembered nothing and felt much rested. Of course, suggestions were constantly given that she would not bite her nails.

The following Sunday, I went over there again. She had not bitten her finger nails since the last time I saw her. I told her to lie down and that in three minutes she would be sound asleep. I used no method whatsoever. In fact, I was in another room. When the three minutes were up, I went in to her and found her in a deep sleep. I impressed on her a number of times that she would never bite her finger-nails again. I placed her in a chair, telling her to open her eyes. She was to see or hear nobody but me. A number of people stood before her, but she could not see them. I asked her a question which she readily answered. Then somebody else asked her the same question, but no answer could be got from her. She seemed perfectly deaf to their words. I asked her if she heard anybody else and she answered 'No.' I next procured a needle which was perfectly clean, and telling her she would feel no pain, I ran

it into her forearm for over half an inch. Very little blood appeared, as I had suggested, and she felt nothing. In fact, after the experiments were over she did not know anything about the wound. Taking a glass of water, I told her it was whiskey. She took a little with some show of difficulty in swallowing and when I told her to walk about the room, she reeled around as though she were overcome by the liquor. I then procured some salt, telling her it was sugar and that it would cure her of her dizziness immediately. She took the salt, a half teaspoonful, said it tasted sweet, asked for more, and was entirely herself again. Finally I placed her between two people putting her head on one's lap and her feet on the other's. She became cataleptic on my suggestion and when two hundred and fifty pounds were put on her body she sustained them very readily.

Before she awakened, I gave her three suggestions: (1) That as soon as she awoke she would go into the front room and lie down on the sofa for a few minutes; (2) that she would go up to her parents and tell them that she was never going to bite her nails again; and (3) that two weeks from that night she would sit down after supper and write me a letter, thanking me for what I had done. All these suggestions were carried into effect.

On Monday, December 9, two weeks and a day after the experiment had been made, I received the following letter:

Dec. 8th, 1901.

DEAR MR. HAYS:

I feel as though I owe you a note of thanks for the wonderful cure you have effected on me. I have not bitten my nails since three weeks ago to-night and I am very proud of them. I am writing this to try to let you know how much I thank you. It seems remarkable that a little thing like hypnotism can do so much good and I shall always feel grateful and indebted to you for this.

Yours sincerely,

E.

Not until after the letter had been sent did she find out that it had been I who prompted her to do it. This young lady has not bitten her finger nails since and is entirely cured.

We have already found the primary cause of the sleep when produced by the tiring of the eyes. The eyelids droop because the muscles become temporarily paralyzed. There is one advantage in placing the hand on top of the head. It is that it rolls the eyeballs upward, thus putting them in a natural position for sleep. The various other processes after the sleep has been produced are all dependent on the workings of the nervous system. Let us first try to explain the cataleptic state—how it is that the arm becomes so rigid that the bones can be broken before the arm will bend. The most plausible explanation to my mind is that impulses are sent from the brain which make one set of muscles counteract the influence of another set. For

example, let us say that two men of equal strength are pulling with all their might on a thick stick. As long as the pull is the same on both sides, the stick won't move. How the mind can exert such an influence we do not know. This same idea of the counter-action of various muscles applies to the whole body as well as to one arm. Yet some one may ask how these muscles can have the power to stand more strain than they do in the waking state. It is only that as our normal selves we never use our full muscle power. This is because not enough stimulation is ever given to the muscle to make it work to its full extent. But in cases of great excitement or danger, even the weakest seem to have superhuman strength.

The loss of the sense of pain or anesthesia can also be accounted for by the brain. When we say we have a pain in our finger, we don't really mean that. The cut is in the finger, but the pain is in the brain, and consciousness is necessary for us to have pain. Suppose a man is going to have an operation on his finger and is made unconscious. Now the finger is there, but the pain has disappeared, showing that pain is not located in various parts of the body, but in the domain of consciousness. So if, under hypnotic influence, you tell the patient that he will have no pain, he thinks the pain away, so to speak—knocks it out of his consciousness.

How we can run needles into people and produce no blood seems still more remarkable, but physiologically it *can* be explained. Let me say here that if any one should pierce a large artery with a needle, serious consequences might result. Let us say that we penetrate the skin in a place where there are thousands of little capillaries. Each one of these vessels is connected with the nervous system by two sets of nerve fibers—those which can dilate the vessels, those which can constrict them. Now, suppose I give the suggestion that I am going to run a needle through a certain part of the arm. An impulse, sent from the brain, constricts the blood vessels at this spot, inhibits the sense of pain, and the needle comes out again wthout a drop of blood following it.

The explanation of the dizziness from water supposed to be whiskey and the cure by salt supposed to be sugar is that both are the result of an unexplainable force whereby the patient takes every word of the hypnotizer as gospel, though it is contradictory to his own ideas. For example, in one case a patient told me that he knew the glass contained water and yet it tasted like whiskey, and he also knew that the sellar contained salt and yet it tasted like sugar.

The cure of the finger-nail habit and all the post-hypnotic suggestions may be summed up briefly. All we should do is to refer back to the perfect or subjective mind where all these suggestions are stored up and say that the objective mind draws nutriment from it, and in

this nutriment these suggestions given under the hypnotic influence come into play.

Before closing this portion of the essay I should like to say that I believe hypnotism is not an occult power, but is a simple, natural physiological process. And again, anybody can use the power just as any one can become a good piano player, or student or business man by training. Yet it is only those with the natural tendency toward personal power who will make the greatest success.

It would indeed be pleasing to me to cite a number of wonderful cases where hypnotism has been used experimentally in order to show the great influence of the mind over the body—how a horse can be ridden over the outstretched body of a man in a cataleptic state, how illusions and hallucinations can be produced, how we may even obtain negative hallucinations, how we can turn an adult into a child, how we can conjure before the mind's eye vistas grand and superb, panoramas gorgeous and elegant, how the commonest man may become an orator, a saint, an assassin perhaps. But all these things would be far beyond the scope of this essay. However, one case seems to be of especial interest as it shows how far hypnotism may be used in the cure of various inflammations.

The experiment is on a nurse 28 years old, who is not at all hysterical. She is a daughter of plain country people, and has been for a long time an attendant in the Zurich Lunatic Asylum, which Forel directs. He thinks her a capable honest person, in no way inclined to deceit. The experiments were as follows: A gummed label was fixed upon her chest on either side; the paper was square. In no case was an irritating gum used. At mid-day Forel suggested that a blister had been put on the left side; and at six o'clock in the evening a moist spot had appeared in that place; the skin was swollen and red around it, and a little inflammation also appeared on the right side, but much less. Forel then did away with the suggestion. On the next day there was a scab on the left side. Forel had not watched the nurse between noon and six o'clock, but had suggested that she could not scratch herself. The other nurses said that the subject could not raise her hand to her chest, but made vain attempts to scratch. Forel repeated the experiment later; he put on the paper at 11:45 a. m. and ordered the formation of blisters in two and one half hours. Little pain was suggested, and the nurse therefore complained but little. At two o'clock Forel looked at the paper on the left side, for which the suggestion had been made, and saw around it a large swelling and reddening of the skin. The paper could with difficulty be removed. A moist surface of epidermis was then visible, exactly square like the paper. There was nothing particular under the paper on the right side. Forel then suggested the disappearance of the pain, inflammation, etc.

In time everything disappeared.

Many investigators have been able to bring about a change in blood supply and other visceral changes of a similar kind. Changes in temperature have been made as much as three degrees centigrade. Bernheim found that by suggestion he could induce local reddening of the skin. This is undoubtedly a vaso-motor change. These local red

spots were often found in the middle ages on the hands of monks and nuns after they had been looking steadily at a cross for hours. At that time it was supposed to be a miracle and a message from the Divinity. In 1860, a woman was found with these spots or blisters caused by something unknown. It was learned that she got these while in the hypnotic state. The wounds healed in the normal way and all that remained to make it necessary for it to be commented upon, was that it gave the investigators the idea of trying to produce these spots by artificial means. Krafft-Ebing, a noted German physician, produced certain results analogous to those cited above. He would put something in the patient's hand and give him the suggestion that it was burning. A reddening would appear. He would take a scissors, a piece of metal and a postage stamp (saying it was a mustard plaster) and would produce the same results.

Wonderful as it may seem—that hypnotic suggestion can produce such grave organic changes—the physician has only to reflect for a moment on the powerful changes which the mind exerts over the course of a disease. He realizes only too well that the mental attitude of the patient toward his malady is of almost as much importance in the cure as the therapeutic measures he may advise. Processes of inflammation are purely physiological in the light of modern medicine and yet there can be no inflammatory process which can not be made worse by concentrated mental worry. A sore finger to the phlegmatic individual is a trifle: but the hysterical woman makes a 'mountain out of a mole hill' of it and thereby actually makes the inflammation worse.

The Uses of Hypnotism.

The general tendency has been in the last decade to use hypnotism indiscriminately; but like every therapeutic agent, it in time will become restricted and only used in certain complaints. It surely should be included by every physician in his 'therapeutic arsenal.' It has one thing in its favor which places it above all remedial agents and that is, that when it is used properly it can do no harm. We must recognize that in all the scientific literature on the subject, there has not a single death been reported from its use. The unscientific application is its abuse.

We must also recognize that there are many cases that are practically incurable by medical treatment, cases which defy the greatest physicians, cases which are surprising because of their persistency. When the last extreme has been reached, when physicians consult and pronounce the case as practically incurable, hypnotism may be tried.

Before the advent of ether or chloroform, the possibility of using hypnotism for anesthetic purposes was thought of and apparently its use in this direction met with success in a limited number of cases.

In 1859, Dr. Guérineau announced that he had amputated a thigh under hypnotic anesthesia. Some other reports are as follows: Jules Cloquent amputated a breast in 1845; Dr. Loysel of Cherbourg amputated a leg and removed some glands in 1846; a double amputation of the legs by Drs. Fanton and Toswel in 1845; amputation of an arm by Dr. Joly in 1845; and in 1847 a tumor of the jaw was removed by Drs. Ribaud and Kiaro of Potiers—all under hypnotic anesthesia (Bernheim's 'Suggestive Therapeutics').

But hypnotism was found to have more drawbacks than advantages in these cases of major surgery. In the first place, hypnotic anesthesia is a difficult state to produce and even a more difficult state to maintain. Secondly, there is always the possibility of the patient awakening unexpectedly and dying from the shock of the operation.

Although it has thus fallen out of use as an anesthetic in these serious cases, still it is used constantly, and more and more every day, in minor surgery. In dentistry it certainly has its place; in out-patient departments of our hospitals it is often of value, as it has no after effects.

The various medical cases that have been treated by the hypnotic method are too numerous to recount. They include nearly every form of mental non-equilibrium and also cases of general organic trouble dependent more or less on the mental attitude of the patient. They include habits of various kinds, such as onycophagie or finger-nail biting, excessive smoking, dypsomania, nervous twitchings, etc., nervous headaches, insomnia and neuralgias; chronic nervous constipation and diarrhœa and dyspepsia; local and general pain, insomnia and neurasthenia. Nor is this all. Hypnotism's greatest blessing consists in the cure of psychic paralytics and psychic hysterics. In this connection we may say that it should be used unconditionally. Dr. Starr in a lecture at the College of Physicians and Surgeons cited a case of paralysis in the left arm from the shoulder to the elbow. A physician knows that it is impossible to get a true paralysis of this kind. Dr. Starr hypnotized the patient in his clinic and in less than three minutes the arm was in as good working order as ever. During the course of the past year, I have worked on a few hysterical cases for physicians where nothing but hypnotism could cure them. A remarkable case of true organic nature came to my notice over a year ago. A lady had a severe swelling on her finger which was so painful that I could hardly bandage it for her. I put her to sleep, suggested the pain away, told her the inflammation would subside the next day and awakened her. I could then do anything I wished to the finger without hurting her.

I have left aside the part that hypnotism plays in mental and moral culture—a phase of the subject so vast that it deserves more consideration than could be given here.

PHYSICIANS AND PHILOSOPHERS.

By Professor CHARLES WILLIAM SUPER,
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ALTHOUGH the initial assonance of physician with philosopher is purely accidental, it is nevertheless a fact that philosophy and the healing art or medical science have been closely associated with each other from their earliest beginnings. It can not but be regarded as a singular coincidence that for two and a half millenniums physic and philosophy, the practitioners of the healing art and the real or professed lovers of knowledge, have been more or less intimate friends. At the beginning they seem to have found themselves in each other's company almost by chance; then by a sort of elective affinity like that which often springs up between persons of opposite sex whose paths in the ordinary course of events incidentally crossed each other, to have discovered that they could make the rest of the journey together to reciprocal advantage.

Herodotus, the Father of History, was a native of Halicarnassus, and Hippocrates, the Father of Medicine, his younger contemporary, first saw the light on the island of Kos, only a few leagues distant. Born in the same year with Hippocrates was the philosopher Diogenes, of Apollonia in Crete, whose few literary remains not only attest his interest in human anatomy, but also furnish proof that he early came under the influence of the Ionian thinkers. Though never regarded as a physician, but only as a philosopher, he tells us in one of the very brief fragments that have been preserved that the veins of the human body are divided into two branches; that they pass through the abdominal cavity along the backbone, one on the right side, the other on the left, into the legs; and that two branches pass into the head. He then goes on to describe the course of the blood vessels and their ramifications as far as the ends of the toes, the fingers, and so on. It may safely be assumed from this fragment that Diogenes gave much attention to the structure of the human body.

In the southwestern portions of Asia Minor, the disciples of Asclepias or Æsculapius had several therapeutic establishments, and it is in connection with these that we discover the first signs of what may be called the healing art in the entire ancient world.

It was especially the priests of the temples of Kos and Knidos who cultivated a primitive and simple medical science in connection with

their service of the god. In this part of Asia, also, philosophy took its rise. For not only was Hippocrates a philosopher as well as a physician, but the same affirmation can be made of a considerable number of Greek thinkers. Diogenes has just been mentioned. Moreover the two lines of investigation were often parallel in other parts of the ancient world. Empedocles who was a full generation older is supposed to have been a physician. Pythagoras, who lived still earlier, though perhaps not a physician in the strict sense of the word, gave, according to tradition, no little attention to the laws of health and formulated a number of precepts supposed to be conducive to its preservation. Plato, though not a special student of the healing art, shows in many passages of his Dialogues, a considerable degree of familiarity with the subject. Aristotle was the son of a physician and was indebted to his father not only for much of his knowledge, but also for his interest in natural history; while his pupil Theophrastus is regarded as the father of medical botany. Among the Romans we find Pliny paying a good deal of attention to facts or supposed facts in the realm of medicine. The same thing is true of Seneca and still more of Vitruvius, though it would perhaps be as far astray to call him a philosopher as a physician in the strict significance of the terms. Toward the latter part of the second century we are carried back again to Asia Minor to find in Galen of Pergamus, not only a distinguished writer on philosophical subjects, but a man whose reputation as a physician is fully equal to, if not greater than, that of Hippocrates, notwithstanding that he was a man of less native capacity. It may be confidently affirmed that Hippocrates, Celsus and Galen represent the entire healing art until modern times. With respect to Cornelius Celsus, who lived in the reign of Tiberius and who occupies an important place in the history of ancient medicine, it must be said that it is uncertain whether he was really a physician. It is rather more than probable that he was a *savant*. On the other hand, the question is raised, Why would any one but a practical physician compile a medical work? Could any other person do it successfully? Another singular fact that has added to the difficulty of defining Celsus' position is that even as late as the age in which he lived nearly all the physicians in Rome were Greek freedmen. At any rate the work of Celsus at once sprang into prominence, and though it is only part of an encyclopedic compilation, nothing else remains at the present day. As is the case with not a few other works of antiquity, its connection with modern times hangs by the slender thread of a single manuscript from which all later copies have been made. This portion of the encyclopedia of Celsus has also an important historical value since it gives brief sketches of more than seventy physicians who had lived

before his time and had attained a certain degree of eminence. It had not escaped his observation that only persons of mediocre ability are loth to admit errors, while the reverse is true of genius, since there still remains a large residuum of truth in its possession.

Apropos of the intimate relationship existing between the study of nature and the healing art, we find that the Romans as early as the time of Cicero called a natural philosopher *physicus,* while the science itself was called *physica,* both words having been borrowed from the Greek *physikos,* that which pertains to nature, from *physis,* nature, in the somewhat restricted sense of the term as used in antiquity. But in medieval Latin *physica* had become the equivalent of *medecina* and *physicus* that of *medicus.* In the older English, physic means both natural philosophy, the modern physics, and the medical art as well as drugs. The restricted signification 'to purge' and 'a purge' is comparatively recent.

Shakspere uses both doctor and physician, the former generally in the sense of teacher. Doctor also occurs in Middle English and later Chaucer speaks of a 'doctour of Phisik.' In classical Latin the term *doctor* means teacher, a sense in which it is used by Cicero, Horace and others. It had no connection with medicine. In modern French *physicien* means one who occupies himself with physics, but in the older language it had the signification of the English physician. The French *médecin,* physician, is evidently from the Latin *medicinus* a derivative from *medicus,* while our medicine, a remedial drug, is from the same word in the feminine gender. In German the connection with the English physician is preserved by *Physikus* alone, a term used to designate an official whose functions correspond in the main with our health-officer. Here too the term *Doktor* has long since usurped the more specific *Artzt,* and *Doktorei* is occasionally used for medicine, 'doctor's stuff.' The Gothic word lèkeis, which is the Anglo-Saxon *laece* and the English 'leech' has nothing in common with either except the meaning. This term doctor again brings to the physician the same title that is borne by the scholar. Although it is given in several departments such as law, theology, music, philosophy, and so on, to the common man both in German and in English countries the doctor represents only the physician. This is explained by the fact that in most communities the only man or men bearing the title were physicians. Of late years, however, especially in the United States, doctors of divinity have become so common, not to mention other doctors, that the designation has reached the stage of painful uncertainty. What it now represents can only be determined by an investigation of each individual on whom it has been conferred.

No more convincing testimony to the small progress made in the healing art from the earliest times until a little more than a century

ago need be asked for than is offered by a comparison of the average length of human life as given by Herodotus and that currently accepted until quite recently—three generations to a century. In fact most life insurance associations have not yet learned that this average is above forty years. Anatomy had made great progress and the structure of the body was minutely known, but until the germ theory of disease and antisepsis were established, therapeutics was largely a matter of tradition and routine; of empiricism and individual skill. When one reads of the incessant wars that kept a portion of the male inhabitants constantly occupied in military enterprises, directly or indirectly, one is inclined to believe that the average of human life must have been shorter than it was held to be twenty or twenty-three centuries ago. There is no room to enter upon a discussion of the problem here; suffice it to say, the loss from disease was probably no greater, and the losses in the armies probably much less relatively than in modern times. For it is well known that the killed in battle are but a small portion of those whom war deprives of life. It is probable that never before or since has any country suffered such ravages as did Germany during what is called the thirty years war. That the sanitary condition of ancient Greece must for the most part have been fairly good is attested by the rapid recuperation of most of the city-states after a disastrous war. But then there were no large cities like those of modern times, in which the population increases much faster than the adoption and enforcement of sanitary measures.

It will hardly be considered surprising that disease in any form should early have stimulated men to reflection. This is true at least of those living under conditions where there was more or less freedom of action and where affairs had not yet settled down into the lethal routine that characterized the social life of most of the people of the ancient world anterior to the appearance of the Greeks. The succession of day and night; the changes of season that follow each other regularly, and the meteorological conditions that accompany them, would be taken as a matter of course. But the vicissitudes of the human system, whether gradual, rapid or sudden, when not the result of accident or attributed to the malevolence of evil spirits, naturally led to inquiry as to their causes. The next step was in quest of prophylactics and curatives. This sort of reasoning, of philosophy, was not obnoxious to the charge that Socrates brought against the philosophy of his day, namely, that it was concerned wholly with things that were of no benefit to any one and with problems to which no answer could be found.

It will scarcely be denied by those best qualified to judge that of the three learned professions that of medicine is still the best fitted to stimulate thought and investigation. It is less hemmed in by tra-

dition, and is of immediate public interest. The man who conquers a dangerous disease or who performs a difficult surgical operation needs no other endorsement. Unless he allows avarice to draw him into a practise more extensive than his constitution will bear, he will have a fair degree of leisure for liberalizing his mind by the study of subjects outside of his particular sphere. The history of modern times no less than that of antiquity offers many examples of medical men whose interests were almost coextensive with those of mankind. That the physician, the investigator, the philosopher and the *litterateur* may be happily blended in one person is finely illustrated by the latest, though it is to be hoped not the last, volume either of the man or of his kind, the 'Aequanimitas' of Dr. Osler.

No one who is acquainted with human nature will be surprised when he learns that the class of medical practitioners known as 'quacks' flourished among the comparatively enlightened Greeks of ancient times. Often, however, the quack is one who strives after results by a method that has been tabooed by the corporation to whose regulations it is assumed that he ought to have subscribed. Though he is an outlaw, before the tribunal of mortals he may be just as good as if he were an in-law. That mysterious and apparently inscrutable part of our being known as the nervous system has always presented problems which medical practitioners have been unable to solve. Why should not a faith-cure be as legitimate as any other cure, provided it is genuine? And there have been faith-cures time out of mind. When persons can not control their own imaginations, the task would seem to be doubly difficult for any one else. Often the most important part of the physician's business is to arouse in his patient the will to get well, and whatever will accomplish this can not be stigmatized as fraud. When hope is lost all is lost. I have known not a few persons who died because they did not want to live or were at least indifferent; and probably an equal number who materially lengthened their lives by the mere determination not to die. My attention was drawn to this phase of pathology many years ago by a curious incident that came under my observation when I was a mere lad. I did not hit upon the explanation until long afterwards. I have seen the same thing repeated many times since then. A vender of medicaments of his own concoction used to visit our neighborhood about twice a year. One day as he was driving along he began to feel unwell, and, contrary to the proverb that doctors never take their own medicines, picked from his chest a vial containing what he believed would afford him relief, and drank some of its contents without looking at the label. Having occasion shortly afterward to leave his wagon to visit one of his customers, it occurred to him that he had drunk from a bottle containing a strong poison. He at once began to feel very sick. A sort of stupor

seized him and he became so weak that he could hardly walk. As soon as he could get back to his medicine-chest he looked at his bottles again, when, to his great joy and greater relief, he found that he had taken just what he intended. The man declared afterwards that he believed he would have died if he had not had the means of ascertaining the facts in the case.

Though the ancients knew little of the structure of the nerves, they were well aware of the influence of the imagination as a therapeutic agency. The walls of many of their temples were covered with tablets and votive offerings in testimony of gratitude to the god by whom the sick were healed. Faith-cures and christian science are therefore by no means a new thing under the sun, but something very old under new names. Though the ancients rarely, or not at all, dissected human bodies, they had a fairly definite knowledge of anatomy derived from the inspection of brutes. The bony structure could be readily studied with the aid of the skeletons that were plentiful enough in countries dotted with battlefields. The Persian invasion alone probably left tens of thousands of corpses strewn along the retreat of the great king. The aversion to the dissection of cadavers that was felt by many of the Greeks seems to have been connected with their reverence for the human form. It was regarded as a sacrilege to mutilate even a corpse. The treatment which the dead body of Leonidas received at the hands of Xerxes was due, as Herodotus expressly informs us, to the extraordinary exasperation he felt against the Spartan king for his fierce resistance to the Persian advance. Though Achilles had dragged the dead body of Hector many times around the walls of Troy, yet Apollo preserved it uninjured. This reverence for the 'human form divine,' like many other superstitions, interfered seriously with the progress of science. The favorite gods, Zeus and Apollo, were represented as physically perfect men. The effects of this sentiment are especially evident in the manner by which those condemned to death were executed. There seems to be no other explanation of the singular custom of administering the hemlock juice than the desire to leave the body after death as nearly as possible as it appeared in its living state. That the rule was departed from under special circumstances and in times of great excitement is no valid argument against the correctness of the explanation.

According to Homer and Herodotus, the healing art was discovered or invented in Egypt. The Odyssey tells us that there every man is a physician skilled beyond human kind. Mention is also made of the many plants possessing medicinal properties. Oculists are said to have been particularly numerous, and many prescriptions for diseases of the eye have been found among the papyri. Artificial and gold-filled teeth have also been met with both in Egypt and in Etrurian

tombs. The practise of medicine was, however, purely empirical, and the rules followed in the treatment of particular diseases were often of great age. The second king of Egypt is said to have been a physician, and another is reported to have written a book on anatomy. The private physicians of both Cambyses and of Darius were Egyptians. The name of the latter brings to mind that of his son Artaxerxes whose private physician was a man of considerable importance in his day, outside of his profession. Ktesias was a native of Knidos, a contemporary of Hippocrates, and no doubt personally known to him. Here we have again the philosopher and the physician in the same person. After acquiring considerable reputation in his own country he had the misfortune to fall into the hands of the Persians. Subsequently he was introduced at court, which proved the beginning of his good fortune. After the battle of Cunaxa he healed the wound inflicted upon his master by the brother of the latter. Later he was employed on a diplomatic mission to his native land; and thus after an absence of seventeen years returned home about 398 B.C., to remain for the rest of his life. That he was well treated by the master whose slave he became, according to Persian parlance, and had abundant opportunities for study, is evident from the fact that he compiled a 'History of Persia,' a work in which he charged Herodotus with frequent falsehoods in what he relates about that country. His scholarly tastes are evinced by this extensive collection, as it must have been, since it was divided into twenty-three books. He also composed a small work on India and one on geography. He is not known to have left any medical writings, and his reputation for impartiality as a historian is not very good. Still it must be regarded as a great misfortune that his extant remains are so meager.

In later times many Egyptian physicians practised in Rome; for to have studied in the land of the Nile, or, still better, to have been born there, was regarded as a special recommendation. Here too magic formulas of all kinds were in frequent use, not only in the compounding of medicines, but in their application. According to Pliny cadavers were dissected by order of the Ptolemies for the purpose of studying fatal diseases. But it can hardly be inferred from this statement that anatomy was regularly pursued in this way, or that dissection was a common practise.

Pliny, who had no very high opinion of the medical fraternity for reasons that will appear farther on, makes the assertion that Rome managed to get along six hundred years without physicians. This is manifestly an exaggeration, since many Greeks professed the healing art in the imperial city much earlier than 150 B. C. But neither did Rome produce a philosopher in the proper sense of the term; certainly no man who loved wisdom for its own sake. The Romans were, how-

ever, an exceptionally healthy people, owing to their fondness for out-door life. This is demonstrated by the rapidity with which they recovered from repeated disasters. Once in a while their capital was invaded by a contagious disorder, then all who could do so left it until the scourge had spent its force, when affairs resumed their natural channel. In fact this was the usual course everywhere until very recently, when the real nature of such diseases was discovered. The ancient Romans were also a singularly hard-headed and practical people; consequently they were almost entirely free from the long list of complaints that are more or less due to the uncontrolled or uncontrollable imagination. Shortly after the Punic wars, but especially under the empire when luxurious habits due to the influx of wealth from the east had debilitated the naturally robust constitutions of the higher classes, nervous disorders, along with many others, were inevitable. Then quacks, charlatans, medicasters, soothsayers, magicians, astrologers and what not found a ready market for their wares. They played upon the credulity of the populace and preyed upon their purses because there was money in both the playing and the preying. No small portion of them probably were shrewd enough to disguise some real medical knowledge under a mass of hocus pocus in order to influence the imaginations of their patients. Well might Ovid say as others had said before him—and since, too—*mundus vult decipi* (people like to be deluded). Physicians still give to their patients who insist 'on taking something' bread pills, colored water and other equally potent or impotent remedies. It would be manifestly unfair to charge a physician with dishonesty because he practises a harmless ruse upon a patient who can be helped in no other way so easily.

"Dismissing faith in the confused creeds of the heathen world, he reposed the greatest faith in the power of human wisdom. He did not know (perhaps no one in that age distinctly did) the limits which nature imposes on our discoveries. Seeing that the higher we mount in knowledge the more wonders we behold, he imagined that nature not only worked miracles in her ordinary course, but that she might, by the cabala of some master soul, be diverted from that course itself. Thus he pursued science across her appointed boundaries into the land of perplexity and shadow. From the truths of astronomy he wandered into astrological fallacy; from the secrets of chemistry he passed into the spectral labyrinth of magic; and he who could be skeptical as to the power of the gods was credulously superstitious as to the power of man." Such are the thoughts that Bulwer-Lytton, in the Last Days of Pompeii, puts into the mind of one of his characters, the Egyptian Arbaces. The reasoning by which such men justified the employment of their superior knowledge and insight to dupe the credulous was half philosophy, half knavery. If a man is the possessor of power

unknown to the multitude except in its effects, why has he not the right to use it?—to use it first of all to enhance his authority and to draw from such authority the advantages that seem to him most desirable? We may well admit that a man of this stamp may have had an inward feeling akin to what we call conscience that would justify his attitude toward his fellows—yet he did not consider these Romans fellow men of his—but it was wholly of the intellect. Such a man is as much a philosopher as were the sophists of an earlier age, and, we may add, of our own day. They apprehend clearly certain superficial verities, but cease to inquire farther after they have discovered what they think needful and sufficient for their own aggrandizement. Far different was the class of witches, one of whom is introduced in the same novel. Against these Horace frequently raises his voice, as do also others of the rationalizing Romans. They are ignorant, and, in most instances, as much the dupes of their own juggleries as their victims. Every man who goes through the world with his mind alert can see specimens without especially looking for them. It is doubtful whether any man has ever lived who had not at least a modicum of superstition in him. However much we may know and however far we may be able to pry into nature in some directions, there are others in which our vision is barred and the unknown is literally within arm's length. The mystery of life and death has always been so profound, as it still is though in a different way, that we need not wonder at the strange aberrations which so many persons fell into, who were in most matters little likely to be carried away by delusions. Sleep, 'the twin brother of death,' has from time out of mind been regarded as an excursion into the realm of departed spirits. If, as many believe, our consciousness is never coextensive with our personality, there are yet many discoveries to be made not dreamt of in the philosophy of most of us. Our will as an integral part of ourselves is the resultant of so many forces and, with the majority, is so little under control of rational motives, that it often plays fantastic tricks, not before high heaven alone, but almost anywhere.

The will of each individual as modified, at least in action from moment to moment, is like a ball thrown into a grove. It strikes one tree, then another and another, and no one can predict with certainty where it will come to rest. This element of chance, of Tyche, in the affairs of men, this incalculable calculus of probabilities, pervades in a remarkable degree the literature of ancient Greece and Rome. It made many feel that, do what they would, they were doomed to be thwarted in their plans. It was only those who, like Socrates, Epictetus and a few others, maintained that the chief end of man is to be found in motives rather than in outward results, who were never thrown out of their philosophical poise by the strange vicissitudes of life.

It is a far cry from the Greeks to the Saracens, though farther in time than in space. Here we find philosophy, or rather metaphysics, and medicine more intimately associated than at any other time or among any other people. Every one of the ten or twelve men who became prominent in Arabian philosophy was a physician. In fact the Arabs treated philosophy as a branch of astronomy and the healing art. The latter served a practical purpose, as did also the former in so far as it was dealt with as astrology. Arab philosophy was, however, something very different from the science that bore the same name among the Greeks. They studied philosophy, or rather they philosophized, as a man would study navigation on a ship lying at anchor. Albeit they were in this respect at no greater disadvantage than the schoolmen. The one party was chiefly concerned to make any discoveries they might light upon harmonize with the Koran and Aristotle; the other with the Bible and Aristotle, with a little spice from Ptolemy thrown in. Al-kindi, the philosopher *par excellence* of the Arabs, flourished in the tenth century. He wrote on almost every imaginable subject from arithmetic to astronomy, though under the former he discusses the unity of God; his arithmetic was therefore something totally different from that which forms the schoolboy's triangle with readin' and 'ritin'. So far as is at present known all his works are lost, except those on medicine and astrology. Roger Bacon ranks him in some respects close to Ptolemy. Al-farabi was a contemporary of the preceding and is generally regarded as the earliest of the Arabian philosophers. However, medical science and even surgery could make little progress where the knowledge of human anatomy was so inadequate. The Koran denounces as unclean every person who touches a dead body, and an article of Mohammedan faith forbids dissection. We should remember, nevertheless, that the founder of anatomy, Vesalius, was sentenced to death by the Inquisition as a magician, and only pardoned on condition that he make a pilgrimage of penance to Jerusalem. This journey cost him his life. And it is probable that he would not have got off even on these relatively hard terms had he not enjoyed the favor of Philip II. of Spain, who esteemed him highly for his medical skill. We have the name of one Arab physician, Abdallatif of Bagdad, who was well aware that anatomy could not be learned from books, strange as it may seem that historians have thought it worth while to place to any man's credit a truth so easily apprehended. The same authority avers that Moslem doctors studied that branch of anatomy known as osteology by examining the bones of the dead found in cemeteries. Averroes of Cordova fills a large place in the history of Moorish philosophy in Spain about the middle of the twelfth century. But in medical renown he ranks far below Avicenna of Bokhara, who flourished about a century and a half earlier. He was teacher of both philosophy and medi-

cine in Ispahan. His medical works seem to have been the chief guide in this branch in Europe for almost five centuries; their sway was not broken until the beginning of the seventeenth century. It is strong and yet painful testimony to the inherent stupidity of mankind, physicians not excepted, that the doctrines of Avicenna are little more than what is found in Galen somewhat modified by Aristotle; and, as we have seen, Galen represents no great advance upon Hippocrates. Alas for the human race that it has always been so much easier to memorize than to think and to investigate! The medical science and practise of the Arabs was confined chiefly to surgery and the empirical treatment of internal diseases. There was no lack of victims in view of the constant wars in which the califs were engaged, and no lack of opportunity for the study of disease in its various forms in the hospitals which some of them founded in various parts of their domains.

Both medical science and philosophy, though not metaphysics, had run their course by the time the Alexandrian era opened. A not inconsiderable number of new facts were collected in Alexandria, but the ability or the will to arrange them into an orderly system was lacking; at least we must adopt this view with the scant evidence to the contrary before us. For more than a thousand years the one question asked was not, What does nature say? What are the facts in the case? but, What does the master say? Beginning with the first christian centuries, Europe and western Asia more and more became organized into a society to suppress the increase of knowledge. It would not be easy to say in which century this organization did the most effective work, though there is no doubt that its most effective instrument was the inquisition. As everybody knows, it was not theology alone that was conservative; law and medicine were equally so. Geothe pays his respects to this attitude of mind when he says in Faust:

> **Hear, therefore, one alone, for that is best, in sooth,**
> **And simply take your master's words for truth.**
> **On *words* let your attention center!**
> **Then through the safest guide you'll enter**
> **The temple-halls of certainty.**

And again:

> **Prepare beforehand well your part**
> **With paragraphs all got by heart,**
> **So you can better watch and look**
> **That naught is said but what is in the book:**
> **Yet in this writing as unwearied be**
> **As did the Holy Ghost dictate to thee.**

This conservatism was a characteristic of the times; the protestant revolution was hardly more than the beginning of a struggle for emancipation in a single direction. It did not enlarge the intellectual horizon of the lawyer or the physician. There is much evidence to show that

with the rise of the belief in witchcraft, medical science, using the term in a very loose sense, received a distinct check. What was the advantage of familiarizing one's self with the nature or usual progress of a disease if its course was constantly liable to be interrupted by the will of some malevolent being possessed of supernatural power? What was to be gained by administering remedies that might at any time be rendered nugatory by the same demoniacal interference? Those who embraced the new faith promulgated by Luther were in some respects worse off than those who clung to the old religion. While catholics and protestants alike believed in witches and other agents of the devil, the former had also their saints and the virgin, to whom they could appeal in time of temptation and distress and who were rarely appealed to in vain. For the latter, Satan and his emissaries were no less real; but he had given up his faith in the efficacy of the intercession of the saints and the virgin. His only resource, therefore, was to protect himself as best he might by dealing mercilessly with those who had anything to do with the black art.

The late Herbert Spencer is said to have reached the conclusion toward the close of his life that man is not a rational being. One can hardly help subscribing to this creed when he learns the attitude of the public toward medical practise. We can understand why there should be a great deal of hazy thinking in matters of law and theology, since they have to do with problems that are at best more or less abstract. But why the public should willfully shut its eyes to practical benefits in every-day matters, matters that so vitally concern its life and health, is hard to understand. Yet it is no harder to understand than why a stone will not of itself roll up hill. We can only realize this mental asphyxiation in the face of overwhelming evidence. It is explicable only from the standpoint of the universal belief in the utter powerlessness of man in the presence of the spirits that surround him and dwell within him. Though the scriptures have much to say about casting out devils, the belief in them is human rather than christian, since it is found among all the peoples of the globe, except among that small class who may be called rationalists; or who, if not themselves entitled to this designation, have inherited a rationalistic creed; for a rationalist is simply one who refuses to believe anything except on such evidence as his reason approves.

There are grounds for believing that Aristotle dissected human bodies; at least on no other grounds can his correct information with regard to certain points in anatomy be explained. But for prudential reasons he did not deem it wise to make public how this knowledge was obtained. Salerno seems to have been the first medical school in Italy outside of Spain, that is, the earliest in charge of christians, and the probability is that its origin has some connection with the Arab

domination. Bologna came into prominence in the thirteenth century and retained its preeminence for a long time. Here we have some definite statements by Mondino that he dissected several cadavers. But his writings also furnish the proof that he was not able to emancipate himself wholly from the authority of Galen and the Arabians. For some reason there were fewer obstacles in the way of the anatomist in Italy than in any other country in Europe; Berenger of Carpi is said to have performed more than a hundred dissections. In Italy too we meet with a number of names that are immortalized by their discoveries in the human body. The chief merit of Vesalius lies in the fact that he clearly recognized for the first time many of the errors that had come into current belief by the authority of Galen.

Hippocrates, Celsus, Galen, these three names sum up the science of ancient medicine; but the greatest of these is Hippocrates. It is perhaps not putting the case too strong if we say that they embrace substantially the entire healing art until not much over a century ago. The medical works of these three authors were printed in Italy before the end of the fifteenth century in Latin translations from the Arabic. This is striking testimony to the completeness of the rupture between ancient Greece and dawning era of modern times. When these Latin translations from the Arabic were made is not known; but it is known that they were very imperfect and that they were as blindly followed as were the writings of Aristotle. Galen's prestige was more due to his ambition and industry than to his individual merit. The great mass of medical knowledge was still accessible in manuscripts. This he carefully examined, and wrote comments upon much of it with remarkable discrimination for his age. Like Aristotle he would have been the first to repudiate the utterly senseless homage paid to his writings. One can not read the works of Hippocrates without being impressed with the extraordinary acumen of the man. Much that now passes current under his name is doubtless not genuine, in the strict sense of the word; but is at least evidence to the prestige of the master's name. The thinker constantly appears along with the practitioner. And we must always keep in mind that chemistry was unknown and the microscope non-existent. He tells us, among other things, that rain water is the purest, while ice and snow water are the worst for all purposes. He had carefully noted the radical differences between the people of Asia and of Europe, so far as he knew these parts of the world. What he says concerns the physician but little, the philosopher a great deal. He directly contravenes popular belief when he tells his readers more than once that there is no such a thing as a sacred disease; that no disorder is sent by a god, and that all ailments are due to natural causes. How heterodox this was may be seen by any one who reads the first book of the Iliad, where Apollo is repre-

sented as having sent a pestilence upon the Greek host. In his discourse on ancient medicine—a singular title for a book written more than four centuries before the christian era, whether by Hippocrates or some one else—we find the idea of the survival of the fittest clearly indicated; in fact, many of the Greeks had more than an inkling of it. His apprehension of gradual evolution is also shown by the assertion that the vegetables used for food are the outcome of experiments with coarser kinds and the deleterious effects upon the health of those that were rejected. He takes the ground that a man can not understand the medical art unless he knows, as far as that is possible, what man is. He holds that the physician should be skilled in nature; but what he defines as 'nature' is not cosmological, it is rather the etiology of disease and the laws of hygiene. He also speaks of the 'common herd of physicians.' Evidently professional pride is not the latest born of time's offspring. Among the most interesting documents included among the writings of Hippocrates is the physician's oath. While it may not have been formulated by the master, it undoubtedly represents the principles of his school. Thus early had Greek physicians formed themselves into a guild and pledged themselves to certain rules of conduct. These guilds were, however, not secret associations or fraternities and had no professional arcana different from those of the present day. The novitiate pledged himself to regard his teacher as equally dear with his own parents; to hold his sons in equal esteem with his own brothers; to teach them and his own sons the medical art without fee, if they desired to learn it; to keep aloof from whatever is detrimental to health; to give no deadly drug even when asked; to pass his life in purity and holiness; to abstain from any harmful act in whatsoever house he might enter for the benefit of the sick; to divulge no secrets connected with his professional practise, and to refuse to administer to any woman a drug that will produce abortion. It is evident from the oath here given in substance that the morals of the medical fraternity were, at least in theory, far in advance of those of the general public and of many well-known philosophers by profession.

SOIL FERTILITY.

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PROBABLY the most important single problem which confronts the farmer to-day is that of the conservation of the fertility of the soil. Fertility may be defined as that condition of the soil which yields the maximum of that material which the plant is capable of using for the best development of those qualities which the farmer desires. Strange as it may seem, just wherein this fertility consists is not yet fully known. Some years ago it was well known, that is to say, it was thought, that all that could be said had been said about it. At the present time, the more thoughtful and cautious among those studying the question of plant growth from a scientific standpoint are by no means settled upon the point. They recognize that there is yet much to be cleared up in regard to it, especially from the physical and the bacteriological sides. The question may be examined from the *chemical, physical, bacteriological* and *ecological* standpoints.

Much has been done in the chemical laboratory—too much, in fact, judging by the results obtained. It was thought that a knowledge of the chemical composition of the soil was the key to the solution of the problem. But it has never been decided just what the chemical composition should be to produce the best results, for the simple reason that it is not known exactly what the requirements of the plants are. Nor does a chemical analysis of the plant itself answer the question. There are certain elements which are no doubt necessary for proper growth, but the analysis of the content of the plant and of the soil does not give a very complete notion of the proper conditions under which certain substances should exist when in the soil. The chemical analysis of soils and fertilizers, though not without considerable importance, is now being relegated to the background in comparison with the physical and the bacteriological conditions. The so-called perfect fertilizers, as sold on the market to the farmer, have been looked upon with some distrust, mainly because they have not produced the results in the production of crops which might be expected from the chemical standpoint. The farmer becomes skeptical and again and again sends samples to the chemist to see if the materials have the proper chemical constituents. The chemist finds it all right, and it *is* all right from his point of view, but to the farmer the results are still unsatisfactory. It is as much to the futile results of the chemical analyses of soils and

fertilizers as applied to the growing of crops as to any other single thing that farmers have been so hostile to 'scientific' farming and to scientific agricultural institutions.

The physical conditions of the soil in regard to fertility are as important perhaps to the farmer as all the others put together, because they are more directly under his control. Yet this has never been fully understood by the farmer, nor has it been developed with agricultural students as it should have been. *Air* and *moisture* are the two most important substances in the soil. The conservation of these and the bringing of them to the roots of the plants is, therefore, one of the chief problems. It is merely the management of these two substances, for they are always present, that the farmer should concern himself with. Timely and suitable cultivation, then, for the development of crops is of the highest importance. Indeed, manuring of soil resolves itself largely into a question of supplying moisture and placing soil in such a condition that the air and moisture are in the best situation for use by the plant. In fact, when a farmer plows under a crop of rye he does not add any material to the soil excepting what the plant obtained from the air, and this is *always* available from the air. The other substances contained in the rye are simply restored to the soil. There is no addition. The rye is, therefore, not a manure in the proper sense, but a means by which the farmer improves the physical conditions.

It is not difficult to see, therefore, that the artificial manures in powder form can not contribute to any very great extent to fertility, if fertility is so largely a physical question. There are conditions of soil, such as size, shape and arrangement of particles, which have to do directly with the air and the water content. The arrangement of the particles can be controlled largely by the farmer.

There is one other force called physical affinity, which is of the highest importance because it is largely through the interaction of this force among the various substances in the soil that plants are capable of extracting solids in solution from it. This physical affinity is exercised among the various soil constituents, each one exerting an influence over the others. Now, if some substance (not in the soil) be added to it, the whole equilibrium may be disturbed by the affinity this may have for the substances already there. A chemical analysis can not determine this. The soil yields up to chemical analysis all that it contains, no matter what the relationship may be among the constituents. To the plant, however, which depends upon a form of physical affinity for its soil food, all the soluble substances will probably not be given up. Therefore, it is a question of physics, as well as one of chemistry, which will determine soil fertility.

When the farmer summer-fallows a field he does not add anything directly by the way of a fertilizer to the field, yet it is much more fertile the year after the summer-fallowing has been done. One benefit of

this operation is the clearing the field of weeds, but, aside from this, the soil is much more productive and, it may be said, more fertile. What is done to the soil in the process of cultivation is to break up the lumps and allow the air to permeate freely, to retain the moisture by making the surface portions fine and porous, thus acting as a 'Campbell blanket,' to mix so thoroughly that the physical affinity of the soil substances becomes changed, the soil being renewed to a very large extent. In this way a farmer can control the fertility without adding any fertilizer. Similar to this is the case already mentioned where the farmer plows under a field of rye. He increases the fertility without adding any fertilizer.

Land should never be allowed to bake or become hard on the surface. If so, air is kept from the roots of the plants. Baking of the soil can be largely controlled by the farmer with certain crops. It occurs, more or less, after rain, depending upon the character of the soil. This crust should be broken up, and kept broken up, by cultivation. In hoeing weeds a man is fertilizing the soil. Weeds, therefore, may be of considerable indirect benefit.

The fable of the farmer dying when on the point of revealing great hidden treasure to his sons illustrates the point. When about to die he told his sons that immense treasure lay buried in the ground on the farm, but death came just before he was able to tell the exact spot. His sons then dug through every inch of soil, over and over again, with the greatest diligence, but did not find any such treasure as they expected to find. The result, however, of such thorough digging was great abundance in the crops. They really did unearth the treasure, but in a far different way from that which they expected.

The bacterial content plays also a very important rôle in the process. Comparatively little is known in regard to the interrelationship existing among these organisms, and of their relations with plants. The processes of nitrifying and denitrifying are in themselves important, but these are probably only an extremely small part of the bacteriological question. And chemical analysis of soils does not throw much light upon it. It is a more complicated problem than a mere chemical one.

Root-tubercles and their production, although a bacterial proposition, require, because of their importance, special mention. The organism which produces the tubercle is capable of extracting nitrogen from the air and rendering it available for the plant upon which the nodule is produced. And these nodules are capable of being produced on many plants of the 'bean' family, such as clover, alfalfa, peas, vetches and the like. The cultivation of such crops, therefore, is productive of additional fertility in nitrogen. The soil, of course, should contain the bacteria peculiar to the plant upon which they work. The soil may contain them already; if not, it should be inoculated. Each farmer,

however, should determine for himself whether his soil needs inoculation. The test is the formation of nodules on the roots. Nodules are more likely to occur on poor soil, especially if it be of a sandy character. If the roots of clover are found to possess nodules, then there is no need of inoculation for that form which grows upon clover. It is similarly true with peas, vetches, alfalfa and the like. The farmer can decide the matter for himself before he makes any outlay for material for inoculation purposes.

It should be said, however, that there is much experimental work yet to be done to show in how far such plants as soy beans enrich the ground for succeeding crops. Some contend that the results are disappointing, especially in the case of the soy bean which produces so large tubercles and in such quantity.

With respect to the ecological aspect of the question it may be said that the growing of mixed crops, cover crops, rotation of crops, and the problem of weeds enter largely into the subject. This involves the relationship existing among different species and the soil conditions. This is comparatively a new aspect of crop conditions, for very little has been done to establish any definite results, although for many years it has been suspected that one plant might exert some injurious or beneficial effects upon others in the same soil, apart from the physical conditions arising out of the relationship. It is quite commonly known that on the ground under trees certain plants will not thrive, for some reason or other, aside from the injury produced by the shading. The tree seems to produce an effect upon the soil injurious to that particular plant. Just how different species of plants react upon one another when growing in the same soil, whether in an injurious manner or not, and just how they affect the soil for a succeeding crop are questions full of promise.

It has recently been asserted that certain parasitic Mucors (molds) are capable of doing what the bacteria of the root-tubercles do for those leguminous plants upon which they work. And the suggestion has also been offered that some Mycorrhizas (root fungi) may serve the office of adding to the available nitrogen supply of the soil. And this may account for the immense growth of pine on sandy barren soil. The Mycorrhizas do serve the function of root hairs, and they may also take the place of the bacteria of the root-tubercles in supplying nitrogen to the host plant.

Soil fertility, then, is not so much a chemical as it is a physical bacteriological and ecological problem. So, whether the soil contain phosphorus, nitrogen, sulphur, potassium, calcium and other elements is not of so much importance as *how* it contains them, and what relationship they have to water, air, to one another, to the soil particles and to the bacterial content of the soil.

SOME OF THE LOCALITIES IN FRANCE AND ENGLAND WHERE MONUMENTS OF THE LATE STONE AND BRONZE AGES HAVE BEEN FOUND.

By J. HOWARD WILSON,
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AS we pass from the earlier periods into the neolithic, the culture and modes of life of our ancestors become more varied and complex; the weapons, implements and ornaments are found in greater number and in almost universal geographical distribution and exhibit an ever increasing diversity of form and perfection of workmanship. All these characters are still more pronounced at the beginning of the bronze age, which is comparatively close to the first confines of the historic period. In the later prehistoric times, the developing culture and, in a measure, civilization, made such progress and became so diversified as to require their division and classification into different groups, each of which demands special study.

In the present brief paper, I have confined myself to a short account of the stone monuments of the late stone and bronze ages, which are found in many parts of the world, and furthermore have restricted it to some of the most famous groups in northern France and southern England.

There would seem to be no well-defined law in regard to the general distribution of the prehistoric stone monuments. They are found all over Europe and Asia, as well as in other parts of the world; at high altitudes above the sea in interior mountain districts, as well as in low lying lands so close to the sea as to be drenched with spray in storms. But the greatest known groups are found, curiously enough, within or near the region which has furnished the most numerous evidences of paleolithic man. This fact may be a mere coincidence and not possessed of any especial significance.

At Carnac, in Brittany, and in the neighboring region is the greatest group in the world of these stone monuments. In one field at Carnac, in eight or more parallel rows, are over 1,100 standing stones or menhirs, while two other groups near-by furnish similar numbers, besides a great number of dolmens with stone-circles and tumuli. On Wiltshire Downs there are said to be over 1,000 tumuli, which, although at first sight seem to be mere mounds of earth, are really megalithic monuments in their more complete form. On Salisbury

Plain is the perfect and well-known monument of Stonehenge, with over three hundred tumuli within a radius of three miles. A few miles further north is the great temple of Avebury, which Sir John Lubbock calls the greatest of all so-called Druidical monuments, and which he says, quoting from Aubrey, 'did as much exceed Stonehenge as a cathedral does a parish church.' Here, originally, were 650 great standing stones, although at present not more than 20 have been left in place, while near by, belonging to the great monument of Avebury.

AVEBURY CIRCLE, WILTSHIRE.

is Silbury Hill, 130 feet high and covering five and one half acres, the largest artificial mound in Europe.

The monuments of Europe have been divided into nine classes, if we follow the classification given in Brittany.

1. Menhirs, meaning, in Breton, 'long stones,' single untrimmed stones placed upright.

2. Alignments, groups of menhirs placed in one or several lines.

3. Lechs, menhirs which have been trimmed, having generally engraved crosses upon their sides, and which are so comparatively recent as to be hardly worthy of consideration as compared with the other prehistoric monuments.

4. Cromlechs, meaning 'circle places,' groups of menhirs arranged to form circles; although in England this term is erroneously used to denote a dolmen or other stone monument.

MENHIRS, NEAR CARNAC, BRITTANY.

DEVIL'S DEN, NEAR AVEBURY, WILTSHIRE.

5. Dolmens, signifying 'table stones,' consisting of a number of menhirs called supports, placed close together to form a rectangle, open at one end and covered by one or more table stones.

6. Covered passages, two lines of parallel menhirs or supports covered by table stones.

7. Stone cists, composed of flat stones forming small closed chambers in the nature of stone coffins.

8. Tumuli, artificial mounds of earth called in England 'barrows,' either oblong or round.

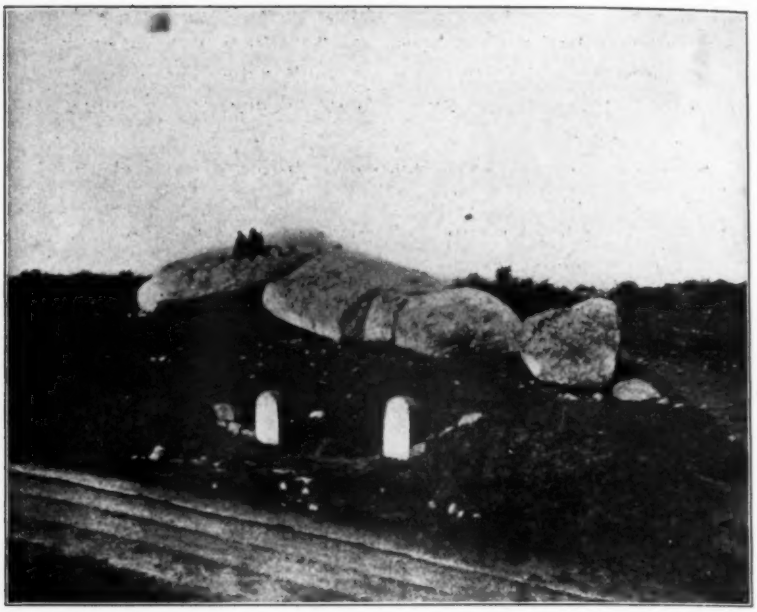
9. Galgals, artificial mounds formed of small stones.

The single standing stone or menhir is probably the oldest form

MENHIR, AVEBURY CIRCLE, WILTSHIRE.

of all these monuments. Very rude peoples would soon naturally employ it for purposes of designation—to mark the grave of a chief or a spot become in some way sacred or important. Then a slab was placed across two or more uprights when an interment took place, and we have the beginning of the dolmen, which later developed into a more or less elaborate chamber, with or without vestibule or covered passage leading to it or auxiliary chambers connected with it; and finally the whole became covered with a mound of earth or small stones, and may have been surmounted by a menhir.

It has been said that the complete megalithic monument consisted of a stone chamber or dolmen covered with a mound, and the whole



THE GREAT MENHIR, LOCKMARIAQUER, BRITTANY.

surmounted by a menhir. In Brittany always, and probably generally, if not always, elsewhere, the dolmen was covered with a mound of earth or small stones. Those dolmens which stand exposed have probably had the earth removed by natural or artificial agencies. In Brittany many of the dolmens show no trace of mounds, standing bare upon the surface of the ground; but it is known that the soil has been removed by the peasants to spread upon their fields, the soil in this part of France being scanty, and the mounds furnishing an available supply. Many of the dolmens and covered passages are still partly underground, the whole of the tumuli not having been removed.

The menhirs vary greatly in size, from a small stone, not over two feet high, to larger ones many times that dimension, and weighing many tons. The greatest of all menhirs is the 'Great Stone' or 'Grand Menhir' at Locmariaquer, in Brittany. It is no longer standing, and is broken into several pieces, but was 70 feet high and weighed 300 tons.

The lechs are considered to be comparatively recent, for all these stone monuments, even in the same region, do not belong to the same period, some dating as far back as the stone age, while others can claim no greater antiquity than the age of bronze or even than a still later time.

The dolmen may be a simple chamber or a number of connecting chambers, and may open directly or may be preceded by a gallery or covered passage of varying length, but it is always open at one end.

The covered passage or *allée couverte* may terminate in a small chamber, made by partitioning off the end of the passage by means of one or more menhirs or supports, so that there would seem to be no sharp line of distinction between the dolmen and the covered passage, each perhaps at times being a modification of the other.

The dolmen seems to be always sepulchral and, as the final resting place of the earthly remains of a chief or a line of important rulers, it must have been regarded as sacred and an object of veneration. At all events it was covered with an elaborate tumulus.

The stone cist appears to be, as a rule, of later age than the dolmen, but was likewise the receptacle of the remains of the dead and was covered with a tumulus or galgal. The great tumulus of Mont Saint Michel at Carnac, which in its eastern part seems to be composed of small stones and thus to be in the nature of a galgal, contains a number of dolmens and stone cists or cists-veu, as they are called in Brittany. A tunnel which has been driven near the base at the eastern end for the purpose of exploration has brought to view dolmens and stone cists with their contents of human bones, ashes, stone implements and ornaments, including some jadeite axes and a collar of white pearls.

The alignments seem to have more of a religious than a mortuary significance, and are associated with the cromlechs or stone circles. The great circular temple of Avebury in England had originally a double row of menhirs leading away from it on two opposite sides.

DOLMEN, AT LOCKMARIAQUER, BRITTANY.

But it is in Brittany, in the region about Carnac, that are found the greatest parallel rows of menhirs with their associated cromlechs. They have here a general east and west alignment. It seems probable that originally the alignments always terminated in a cromlech, or were connected or associated with one in some way, but at present often a trace only remains of the cromlech and even this may be lacking.

The field of Ménec contains 1,100 of these great stones arranged in 11 lines and terminating at their western extremity in a cromlech composed of 70 menhirs. In the field of Kermario are 982 menhirs in ten rows, the largest of the stones being about 20 feet high. The field of Kerlescan contains a rectangular cromlech or quadrilateral of

ALIGNMENTS NEAR CARNAC, BRITTANY.

39 menhirs, with 579 menhirs in 13 lines. At Erdeven, a few kilometers to the west, are the alignments of Kerzehro, composed of 1,129 menhirs in 10 rows. At right angles to these, and extending in a northerly direction, is a line of 23 menhirs, the largest being 18 feet high, which may possibly be the remnant of a great cromlech. Besides these great groups, near Carnac are numerous others of less importance either connected with these or occupying independent positions, while all about are scattered innumerable menhirs and dolmens, including some magnificent specimens, with occasional tumuli and other monuments.

Excavations and explorations made about the alignments and cromlechs have yielded practically nothing in the way of relics, save a few

fragments of stone implements and pottery and some Gallo-Roman objects, all of which have been probably lost or accidentally introduced into the soil near the monuments. These monuments then are apparently not tombs nor in any way sepulchral. There would appear to be little doubt that the alignments and cromlechs are a sort of temple, the alignments with the avenues between being comparable to the columns and the aisles of a cathedral, and the cromlech at the end to the altar or inner sanctuary.

At Avebury and Stonehenge the interments have been made in barrows near the cromlechs; within three miles of Stonehenge, as has been mentioned, are over three hundred of these barrows, which have

MENHIRS, AVEBURY CIRCLE, WILTSHIRE.

yielded interesting relics to the excavations and efforts of investigators. The cromlechs themselves, here as elsewhere, are evidently temples. There seems to be no trace of any alignments at Stonehenge, but in their place is the double circle, the inner composed of smaller stones being considered the original, and the outer and more striking, much more recent. Avebury had originally two double rows of menhirs leading to it from opposite sides, but few of these stones now remain. Avebury differs from Stonehenge and the cromlechs of Morbihan in several important particulars. It consists mainly of a great circular earthwork within which is a ditch or sort of dry moat, containing twenty-eight and one half acres. Inside the ditch was the principal

ENTRANCE, TABLE DES MARCHANDS, LOCKMARIAQUER, BRITTANY.

circle of great stones, while within the area enclosed were two small circles formed with a double row of smaller stones.

Occasionally the interior surface of a support in some dolmen or covered passage is found to be engraved with curious figures. Generally, they seem to be circles or some form of curved lines, and at times there is a figure representing the stone celt,* which was an object of veneration even after it ceased to be employed as a tool or weapon. Some of the best examples of these are in the famous dolmen on the island of Gavr'inis at Locmariaquer.

The meaning of these curious circles and curves has never been explained. They are probably symbolical or the characters used to denote some definite idea among the people who made them, or may be simply decorative, although this latter interpretation I believe to be far less probable. Certain linguists have at times claimed to see in some of them modifications of hieroglyphics or letters of ancient languages. A controversy has arisen as to the nature of the instrument

* The figure of a celt is engraved on the under surface of the cap stone of the dolmen Table des Marshands.

employed to cut these characters into the faces of the hard rocks. Some archeologists claim that the work could not possibly have been done without the use of metal tools; others assert as positively, and apparently prove their case, that the engraving could have been done by means of stone engravers alone. A determination of this question would shed a certain amount of light upon the age of these monuments, especially as to the age of the particular ones bearing these characters, but this question is unimportant, their antiquity as a whole or as to type being determined in other ways.

Of course, many interesting legends have grown up in regard to these mysterious monuments of the past which are still believed in by

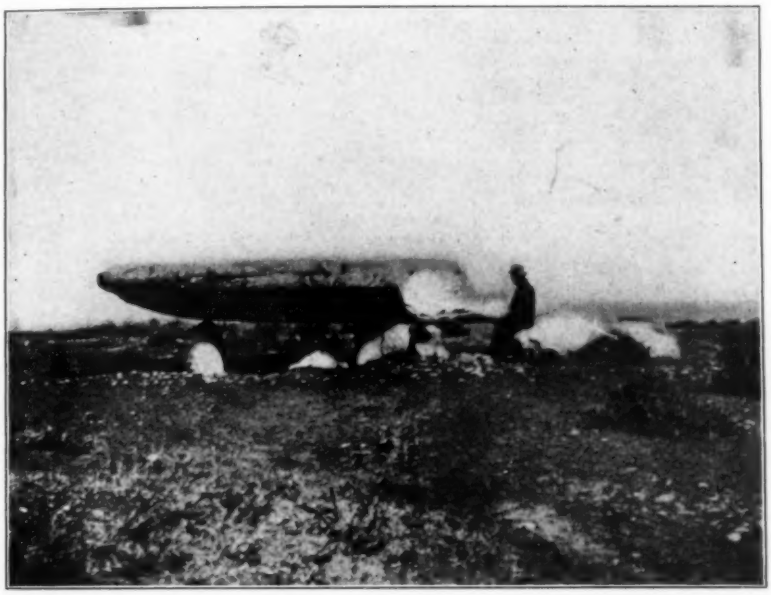


TABLE DES MARCHANDS, LOCKMARIAQUER, BRITTANY.

the superstitious peasants. In regard to a group of menhirs in the western part of Brittany near the coast, it is claimed that every one hundred years on St. Sylvester's Eve, the great stones rush down to the sea for a drink of the salt water, and while they are gone, one may find untold treasures of gold and precious stones in the hollows over which they stood. But woe to the, over-covetous, who in greed for more delays too long, and is crushed by the great stones on their return. There is a legend also in regard to the origin of the marvelous alignments of Carnac. It seems that a saint was being hunted down by the pagans, and reaching the sea, could go no further. He turned and invoking his miraculous powers stretched forth his hand and turned them into stone. Another version makes them Roman soldiers in line

DOLMEN, NEAR CARNAC, BRITTANY.

of battle, but why so many were needed to overcome one poor saint is not stated. Old customs and superstitions cling long to a rude uncultured people. They change slowly. While accepting the new ideas or religion, they do not give up the old. Both may flourish side by side.

Some of the stone monuments of Brittany were probably reared or constructed as late as the christian era. As late as the time of Gregory of Tours, the worship of stone monuments was still so prevalent as to call forth an edict of the church putting under a ban all who persisted in still adhering to it, while in some of the remote valleys of the Pyrenees, according to some of the best authorities, the worship of stone exists at the present day.

There seems to be considerable evidence that the people who built Stonehenge and Avebury and erected the menhirs and alignments of Brittany were sun-worshipers, and while a monolith or megalithic monument may have been regarded with veneration and worshipped itself, originally it was simply the symbol and representative of something greater. These customs would not die out easily among a rude clannish people even after the introduction of Christianity, and furthermore, we are all sun-worshipers more or less.

The age of these marvelous and mysterious monuments can not be told in years, but in a more general way. They are not all of the same age; some date as far back as the Neolithic period, many belong to the age of bronze, while others are as recent as the christian era. Since

some of these stones in Brittany were put in place, there has been a noticeable subsidence of the coast, so that now some are only revealed at low tide. On the island of Erlanic in the Gulf of Morbihan is half of a cromlech; the other half with the whole of another circle tangent to the first is under water. But this subsidence of the land since these monuments were built would not necessarily indicate any great antiquity, for appreciable movements of the earth's crust, producing changes in level, have taken place in this region in comparatively recent times.

Most of the monuments of Brittany, with the exception of the lechs, which are known to be comparatively recent, seem to be of unhewn stone and many undoubtedly belong to some part of the Neolithic period, while others belong to the bronze. Stonehenge has been satisfactorily determined to belong to the bronze age, from its apparent association with the barrows which surround it. An examination of many of these barrows has revealed many bronze instruments and ornaments and determined them as belonging to that age. Avebury is probably much older, consisting entirely, besides the earthwork, of unhewn menhirs, while almost all the stones of Stonehenge are trimmed and squared, and the great outer circle is furnished with oblong, squared capping stones. And more than this, the capping stones dovetail into each other and are secured on their supports by means of hollows on their under surfaces fitting over bosses on the supports.

DOLMAN, NEAR CARNAC, BRITTANY.

Before closing this brief paper, it is interesting to note the engineering problem presented by the capping stones, both at Stonehenge and on the dolmens. How were they placed in position? They could hardly have been slid into position without overturning the supports. It would seem as if they must have been lowered from above or else that the supports were buried to their tops until the table stones were placed in position, and then dug out. The erection of the great menhirs presents a similar problem. Those who placed them in position may have resorted to the inclined plane, rolled them up and then tilted them over the vertical edge. The placing in position of these table stones, which often weigh many tons, as well as the erection of the great menhirs, certainly required a considerable amount of engineering skill, and we are here, as well as when confronted by the great feats of other ancient peoples, somewhat surprised at the early date at which it made its appearance. The tourist, scientist or archeologist, in viewing the great monuments in Wiltshire and in Morbihan, can hardly fail to be impressed by the magnitude of the works undertaken and completed in these prehistoric times, nor can the observer overlook their significance in regard to the lives and culture of the builders.

THE VALUE OF NON-EUCLIDEAN GEOMETRY.

BY PROFESSOR GEORGE BRUCE HALSTED,

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* Among conditions to a more profound understanding of even very elementary parts of the Euclidean geometry, the knowledge of the non-Euclidean geometry can not be dispensed with.—E. Study.

ELEMENTARY geometry has been the most stable part of all science. This was due to one book, of which Philip Kelland says:

> It is certain, that from its completeness, uniformity and faultlessness, from its arrangement and progressive character, and from the universal adoption of the completest and best line of argument, Euclid's Elements stand pre-eminently at the head of all human productions. In no science, in no department of knowledge, has anything appeared like this work: for upwards of 2,000 years it has commanded the admiration of mankind, and that period has suggested little towards its improvement.

In all lands and languages, in all the world, there was but one geometry. For the abstractest philosophy, for the most utilitarian technology, geometry is of fundamental importance. For education it is the before and after, the oldest medium and the newest; older, more classic than the classics, as new as the automobile. The first of the sciences, it is ever the newest requisite for their ongo. Says H. J. S. Smith:

> I often find the conviction forced upon me that the increase of mathematical knowledge is a necessary condition for the advancement of science, and, if so, a no less necessary condition for the improvement of mankind. I could not augur well for the enduring intellectual strength of any nation of men, whose education was not based on a solid foundation of mathematical learning, and whose scientific conceptions, or, in other words, whose notions of the world and of the things in it, were not braced and girt together with a strong framework of mathematical reasoning.

Of what startling interest then must it be that at length this century-plant has flowered, a new epoch has unfolded. How did this happen? Euclid deduced his geometry from just five axioms and five postulates. These were all very, very short and simple, except the last postulate, which was in such striking contrast to the others that not its truth, but the necessity of assuming or postulating it, was doubted from remotest antiquity. The great astronomer Ptolemæos (Ptolemy) wrote a treatise purporting to prove it, and hundreds after him spent their brains in like attempts. What vast effort has been wasted in this chimeric hope, says Poincaré, is truly unimaginable!

This most celebrated, most notorious of all postulates, Euclid's parallel-postulate, is not used for his first 28 propositions. When at length used, it is seen to be the inverse of a proposition already demonstrated, the seventeenth, as Proklos remarked, therefrom, according to Lambert, arguing its demonstrability. Moreover, its one and only use is in proving the inverse of another proposition already demonstrated, the twenty-seventh. No one had a doubt of the necessary external reality and exact applicability of the postulate. The Euclidean geometry was supposed to be the only possible form of space-science; that is, the space analyzed in Euclid's axioms and postulates was supposed to be the only non-contradictory sort of space. Even Gauss never doubted the actual reality of the parallel-postulate for our space, the space of our external world, according to Dr. Max Simon, who says in his 'Euclid,' 1901, p. 36:

> Nur darf man nicht glauben, dass Gauss je an der thatsächlichen Richtigkeit des Satzes für unsern Raum gezweifelt habe, so wenig, wie an der der Dreidimensionalität des Raumes, obwohl er auch hier das logisch Hypothetische erkannte.

But could not this postulate be deduced from the other assumptions and the 28 propositions already proved by Euclid without it? Euclid had among these very propositions demonstrated things more axiomatic by far. His twentieth, 'Any two sides of a triangle are together greater than the third side,' the Sophists said, even donkeys knew. Yet, after he has finished his demonstration, that straight lines making with a transversal equal alternate angles are parallel, in order to prove the inverse, that parallels cut by a transversal make equal alternate angles, he brings in the unwieldy assumption thus translated by Williamson (Oxford, 1781):

> 11. And if a straight line meeting two straight lines makes those angles which are inward and upon the same side of it less than two right angles, the two straight lines being produced indefinitely will meet each other on the side where the angles are less than two right angles.

This ponderous assertion is neither so axiomatic nor so simple as the theorem it is used to prove. As Staeckel says:

> It requires a certain courage to declare such a requirement, alongside the other exceedingly simple axioms and postulates.

Says Baden Powell in his 'History of Natural Philosophy,' p. 34:

> The primary defect in the theory of parallel lines still remains.

This supposed defect an ever renewing stream of mathematicians tried in vain to remedy. Some of these merely exhibit their profound ignorance, like Ferdinand Hoefer, who in his 'Histoire des Mathématiques,' Paris, 1874, p. 176, says:

> Certain defects with which Euclid is reproached may be explained by simple transpositions. Such is the case of the Postulatum V.

He then proceeds to misquote it as follows:

> Si une droite, en coupant deux autres droites, fait les angles internes inégaux, ou moindres que deux angles droits, ces deux droits, prolongées à l'infini, se rencontreront du côté où les angles sont plus petits que deux droits;

and continues,

> It is certain that, placed after the definitions, this Postulatum is incomprehensible. But, placed after Proposition XXVI. of the first book, where the author demonstrates that 'if the interior angles together equal two right angles, the lines will not meet,' it acquires almost the evidence of an axiom.

The XXVI. is, of course, a mistake for XXVIII.

Other mathematicians have tried to turn the flank of the difficulty by substituting a new definition of parallels for Euclid's.

Eu. I., Def. 35, is: 'Parallel straight lines are such as are in the same plane, and which being produced ever so far both ways do not meet.'

On this Hobbs petulantly remarks:

> How shall a man know that there be straight lines which shall never meet, though both ways infinitely produced?

The answer is simple: Read Eu. I., 27, where if the straight line be infinite, is proven that those making equal alternate angles nowhere meet.

Wolf, Boscovich and T. Simpson substitute for Euclid's the definition: 'Straight lines are parallel which preserve always the same distance from each other.' But this is begging the question, since it assumes the definition, 'two straight lines are parallel when there are two points in the one on the same side of the other from which the perpendiculars to it are equal,' and at the same time assumes the theorem, 'all perpendiculars from one of these lines to the other are equal.'

Just so the assumption that there are straights having the same direction is a *petitio principii,* since it assumes the definition of Varignon and Bézout, that 'parallel lines are those which make equal angles with a third line,' and at the same time assumes the theorem that 'straight lines which make equal angles with one given transversal make equal angles with all transversals.'

Other and more penetrating geometers have proposed substitutes for the parallel-postulate. Of these the simplest are Ludlam's: 'Two straight lines which cut one another can not *both* be parallel to the same straight line,' and W. Bolyai's 'Any three points are costraight or concyclic.'

But the largest and most desperate class of attempts to remove this supposed blemish from geometry consists of those who strive to deduce the theory of parallels from reasonings about the nature of the straight line and plane angle, helped out by Euclid's nine other assumptions

and first twenty-eight propositions. Hundreds of geometers tried at this. All failed. That eminent man, Legendre, was continually trying at this, and continually failing at it, throughout his very long life.

Naturally, some very respectable mathematicians were deceived. The acute logician, De Morgan, accepted and reproduced a wholly fallacious proof of Euclid's parallel postulate, recently republished as sound by the Open Court Publishing Company, Chicago, 1898. A like pseudo-proof published in *Crelle's Journal* (1834) trapped even our well-known Professor W. W. Johnson, head mathematician of the U. S. Naval Academy, who translated and published it in the *Analyst* (Vol. III., 1876, p. 103), saying:

> This demonstration seems to have been generally overlooked by writers of geometrical text-books, though apparently exactly what was needed to put the theory upon a perfectly sound basis.

But a more recent, a veritably shocking, example is at hand. On April 29, 1901, a Mr. Israel Euclid Rabinovitch submitted to the Board of University Studies of the Johns Hopkins University, in conformity with the requirements for the degree of doctor of philosophy, a dissertation in which, after an introduction full of the most palpable blunders, he proceeds to persuade himself that he proves Euclid's parallel postulate by using the worn-out device of attacking it from space of three dimensions, a device already squeezed dry and discarded by the very creator of non-Euclidean geometry, John Bolyai. And his dissertation was accepted by the referees. And since then Dr. (J. H. U.) Israel Euclid Rabinovitch has written, March 25, 1904:

> As to Poincaré's assertion about the impossibility to [sic] prove the Euclidean postulate, it is no more than a belief—though an enthusiastic one [sic]—never proved mathematically, and in its very nature incapable of mathematical proof.
>
> Poincaré is undoubtedly a great mathematician, perhaps the greatest now living; but his assertion of his inmost conviction, no matter how strongly put, can not pass for mathematical truth, unless mathematically proved.
>
> His conclusion—shared also by many another noted mathematician as well as by the founders of the non-Euclidean geometries—can only be based on the fact of the existence of these last geometries, self-consistent and perfectly logical. But this is a poor proof of the impossibility to [sic] establish the Euclidean postulate.
>
> If space is regarded as a point-manifold, it is Euclidean, and the postulate can be proved as soon as we are allowed to look for its establishment in three-dimensional geometry.
>
> The two-dimensional elliptic geometry described by Klein, Lindemann and Killing, according to my opinion, is an absurdity for a point-space in the ordinary sense of the term.
>
> Poincaré says that all depends upon convention. But still he deduces from this the perfectly gratuitous conclusion that therefore the parallel-postulate can not be proved.

Alongside this modern instance, too pathetic for comment, we may, however, be allowed to quote what one of the two greatest living mathematicians, Poincaré, says in reviewing the work of the other, Hilbert's transcendently beautiful 'Grundlagen der Geometrie,' itself an outcome of non-Euclidean geometry:

What are the fundamental principles of geometry? What is its origin; its nature; its scope?

These are questions which have at all times engaged the attention of mathematicians and thinkers, but which took on an entirely new aspect, thanks to the ideas of Lobachevski and of Bolyai.

For a long time we attempted to demonstrate the proposition known as the *postulate of Euclid;* we constantly failed; we know now the reason for these failures.

Lobachevski succeeded in building a logical edifice as coherent as the geometry of Euclid, but in which the famous postulate is assumed false, and in which the sum of the angles of a triangle is always less than two right angles. Riemann devised another logical system, equally free from contradiction, in which the sum is, on the other hand, always greater than two right angles. These two geometries, that of Lobachevski and that of Riemann, are what are called the *non-Euclidean geometries.* The postulate of Euclid then can not be demonstrated; and this impossibility is as absolutely certain as any mathematical truth whatsoever.'

It was the attainment of this very perception which in fact led to the creation of the non-Euclidean geometry. Says Lobachevski in the introduction to his 'New Elements of Geometry':

The futility of the efforts which have been made since Euclid's time during the lapse of two thousand years awoke in me the suspicion that the ideas employed might not contain the truth sought to be demonstrated. When finally I had convinced myself of the correctness of my supposition I wrote a paper on it [assuming the infinity of the straight].

It is easy to show that two straights making equal angles with a third never meet.

Euclid assumed inversely, that two straights unequally inclined to a third always meet.

To demonstrate this latter assumption, recourse has been had to many different procedures.

All these demonstrations, some ingenious, are without exception false, defective in their foundations and without the necessary rigor of deduction.

John Bolyai calls his immortal two dozen pages (the most extraordinary two dozen pages in the whole history of thought), 'The Science Absolute of Space, independent of the truth or falsity of Euclid's Axiom XI. (which can never be decided *a priori*).'

Later we read on the title page of W. Bolyai's 'Kurzer Grundriss': 'the question, *whether two straights cut by a third, if the sum of the interior angles does not equal two right angles, intersect or not?* no one on the earth can answer without assuming an axiom (as Euclid the eleventh)' [the parallel postulate].

With the ordinary continuity assumptions or the Archimedes postulate, it suffices to know the angle-sum in a single rectilineal triangle in order to determine whether space be Euclidean or non-Euclidean.

How peculiarly prophetic or mystic then that the clairvoyant inspiration of the genius of Dante, the voice of ten silent centuries, should have connected with the wisdom of Solomon and the special opportunity vouchsafed him by God a question whose answer would have established the case of Euclidean geometry seven hundred years before it was born, or that of non-Euclidean geometry three thousand years before its creation.

I. Kings 3: 5 is:

In Gibeon the Lord appeared to Solomon in a dream by night: and God said, Ask what I shall give thee.

Then says Dante of his asking,

'Twas not to know the number in which are
. . . . . .
Or if in semicircle can be made
Triangle so that it have no right angle.
O se del mezzo cerchio far si puote
Triangol sì, ch'un retto non avesse.
Par. C. XIII. 101–102.

How startling this! How strangely reinforced by the fact that in the fourth canto of the 'Divina Commedia,' with Cæsar greatest of the sons of men, Dante ranks, among exalted personages

. . . who slow their eyes around
Majestically moved, and in their port
Bore eminent authority:

Hippocrates of Chios, who found the quadrature of the lune (nearest that ever man came to the quadrature of the circle until finally John Bolyai squared it in non-Euclidean geometry and Lindemann proved no man could square it in Euclidean geometry); Euclid, the geometer, the elementist, preemptor, by his postulate, of the common universe, Euclidean space; and then Ptolemy, first of the long line of those who have tried by proof to answer the question Dante says Solomon might have asked God and did not, a question crucial as to whether Euclid or Bolyai owns the real world.

Anyhow, the shock currents to scientific somnolence and complacency breaking in to the entrenched thought camp from over the ramparts on the far frontiers almost simultaneously at Kazan on the Volga and at Maros-Vásárhely in far Erdély, started an ever-deepening movement to sift, to revise the foundations of geometry, then of all mathematics, then of all science, a movement of which the latest, as the most charming and weightiest, outcome is that pair of wonder-books, Poincaré's 'Science and Hypothesis' and 'The Value of Science.'

It was formerly customary to consider the assumption that space is a triply extended continuous number-manifold as a self-evident outcome of the continuity relations of space and the curves and surfaces in it. But since the rise of non-Euclidean geometry, it has come more and more to be seen that such presupposition about space is only admissible when one has already established and developed elementary geometry synthetically. Lobachevski stressed this in 1836 in his introduction to the 'New Elements,' where he says:

One must necessarily make the beginning with synthesis, in order, finally, after one has found the equations, therewith likewise to reach the limit beyond which now all goes over into the science of numbers.

For example, one demonstrates in geometry that two straights perpendicular to a third never meet; that the equality of triangles follows from that of certain of their parts.

> In vain would one seek to treat analytically propositions of this species, even as all the theory of parallels. One would never succeed, just as one would not be able to do without synthesis for measuring plane rectilineal figures, or solids terminated by plane surfaces. It is incontestible that in the beginnings of geometry or mechanics, analysis can not serve as sole method.
>
> One may compress the circle of synthesis; but it is impossible completely to suppress it.

From this, however, it follows that all investigations, such as those of Sophus Lie which start with the idea of number-manifold, involve a *petitio principii,* if interpreted directly as researches on the foundations of geometry. In the same way, the non-Euclidean geometry stops the old wrangle as to whether the axioms of geometry are *a priori* or empirical by showing that they are neither, but are conventions, disguised definitions, or unprovable assumptions pre-created by auto-active animal and human minds.

As Lambert insisted, for the space problem the mathematical treatment is in essence the treatment by logic. The start is from a system of axioms, assumptions. We postulate that between the elements of a system of entities certain relations shall hold, *e. g.,* two *points* determine a *straight,* three a *plane.* There is to be shown that these axioms are independent and not contradictory, presupposing pure logic and the applicability to the entities of an arithmetic founded by and made of pure logic. That the assumptions considered should be axioms *of geometry,* they must satisfy a further condition, which Hilbert formulates thus:

> A system of assumptions is called a system of axioms of geometry if it gives the necessary and sufficient and independent conditions to which a system of things must be subjected in order that every property of these things should correspond to a geometric fact, and inversely; so that therefore in Hertz's sense these things should be a complete and simple picture of geometric reality.

The physiologic-psychologic investigation of the space problem must give the meaning of the words *geometric fact, geometric reality.*

It is the set of assumptions which makes the geometry what it is, which determines it. Thus, in my 'Rational Geometry,' one system of assumptions about the elements, points and straights on a plane, makes Euclidean planimetry. Another set makes Riemannean planimetry, in which when we picture it as in Euclidean space, we may call the straights straightests (great circles), and the plane sphere.

In the light of all this we see how the importance of non-Euclidean geometry for the teacher is still emphasized by the text-books of France, which have never recovered from Clairaut and Legendre. Even the latest and best French geometry, that of Hadamard, published under the editorship of Gaston Darboux, never presents nor consciously considers the question of its own foundations. It seems childishly unconscious of what is now requisite for any geometry pretending to be scientific or rigorous. This lack of foundation is allowable in a preliminary

course of intuitive geometry which does not attempt to be rigorously demonstrative, which emphasizes the sensuous rather than the rational. But in a serious work it is now no longer permissible to have nothing to start from. Wherever rigorous mathematics, there pure logic.

It may be a relief to many that the non-Euclidean geometry has shown the limitations to the arithmetization of mathematics. The opinion that only the concepts of analysis or arithmetic are susceptible of perfectly rigorous treatment Hilbert considers entirely erroneous.

> On the contrary, he says, I think that wherever, from the side of the theory of knowledge, or in geometry, or from the theories of natural or physical science, mathematical ideas come up, the problem arises for mathematical science to investigate the principles underlying these ideas and so to establish them upon a simple and complete system of axioms, that the exactness of the new ideas and their applicability to deduction shall be in no respect inferior to those of the old arithmetical concepts.
>
> The arithmetical symbols are written diagrams and the geometrical figures are graphic formulas.
>
> The use of geometrical signs as a means of strict proof presupposes the exact knowledge and complete mastery of the axioms which underlie those figures; and in order that these geometrical figures may be incorporated in the general treasure of mathematical signs, there is necessary a rigorous axiomatic investigation of their conceptual content.

In other words, the world has outgrown Wentworth's geometry. More than this, as Frankland puts it, the possibility of explaining 'mass' (the fundamental property of matter) as a function of 'electric charge' is on the point of banishing both ordinary gross matter and also ether, since the principle of parsimony forbids needless hypothetical entities. Now the relation between the two opposite electricities so closely resembles that between Bolyaian and Riemannean space that, as Clifford adumbrated, we may expect to see matter, ether and electricity banished in favor of *space,* the various and changing geometries of which will be found adequate to account for all the phenomena of the material world.

Furthermore, these geometries of physical space will be found not to be 'continuous,' but to be the varied and changing 'tactical' arrangements of a *discrete,* a discontinuous manifold consisting of indivisible units. The notion of continuous extension, so long considered ultimate, will, by this simplification, be subsumed under the finally ultimate notion of juxtaposition, with which Lobachevski begins his great treatise 'Noviya nachala,' in whose very first article he says of it: "This simple idea derives from no other, and so is subject to no further explanation."

UNIVERSITY EDUCATION AND NATIONAL LIFE.*

By Sir RICHARD C. JEBB, Litt. D., D.C.L., M.P.

EVERY country has educational problems of its own, intimately dependent on its social and economic conditions. The progressive study of education tends, indeed, towards a certain amount of general agreement on principles. But the crucial difficulties in framing and administering educational measures are very largely difficulties of detail; since an educational system, if it is to be workable, must be more or less accurately adjusted to all the complex circumstances of a given community. As one of those who are now visiting South Africa for the first time, I feel that what I bring with me from England is an interest in education, and some acquaintance with certain phases of it in the United Kingdom; but with regard to the inner nature of the educational questions which are now before this country, I am here to learn from those who can speak with knowledge. In this respect the British Association is doing for me very much what a famous bequest does for those young men whom it sends to Oxford; I am, in fact, a sort of Rhodes scholar from the other end—not subject, happily, to an age limit—who will find here a delightful and instructive opportunity of enlarging his outlook on the world, and more particularly on the field of education.

As usage prescribes that the work of this section, as of others, should be opened by an address from the chair, I have ventured to take a subject suggested by one of the most striking phenomena of our time —the growing importance of that part which universities seem destined to play in the life of nations.

Among the developments of British intellectual life which marked the Victorian age, none was more remarkable, and none is more important to-day, than the rapid extension of a demand for university education, and the great increase in the number of institutions which supply it. In the year 1832 Oxford and Cambridge were the only universities south of the Tweed, and their position was then far from satisfactory. Their range of studies was too narrow; their social operation was too limited. Then, by successive reforms, the quality of their teaching was improved, and its scope greatly enlarged; their doors were opened

* Address by the president to the Educational Science Section of the British Association for the Advancement of Science, South Africa, 1905.

to classes of the community against which they had formerly been closed. But meanwhile the growing desire for higher education—a result of the gradual improvement in elementary and secondary training—was creating new institutions of various kinds. The earliest of these arose while access to Oxford and Cambridge was still restricted. The University of Durham was established in 1833. In 1836 the University of London, as an examining and degree-giving body, received its first charter. A series of important colleges, giving education of a university type, arose in the greater towns of England and Wales. The next step was the formation of federal universities. The Victoria University, in which the Colleges of Manchester, Liverpool and Leeds were associated, received its charter in 1880. The Colleges of Aberystwyth, Bangor and Cardiff were federated in the University of Wales, which dates from 1893. The latest development has been the institution of the great urban universities. The foundation of the University of Birmingham hastened an event which other causes had already prepared. The federal Victoria University has been replaced by three independent universities, those of Manchester, Liverpool and Leeds. Lastly, a charter has recently been granted to the University of Sheffield. Then the University of London has been reconstituted; it is no longer only an examining board; it is also a teaching university, comprising a number of recognized schools in and around London. Thus in England and Wales there are now no fewer than ten teaching universities. Among the newer institutions there are some varieties of type. But, so far as the new universities in great cities are concerned, it may be said that they are predominantly scientific, and also that they devote special attention to the needs of practical life, professional, industrial and commercial; while at the same time they desire to maintain a high standard of general education. It may be observed that in some points these universities have taken hints from the four ancient universities of Scotland—which themselves have lately undergone a process of temperate reform. The Scottish universities are accessible to every class of the community; and the success with which they have helped to mold the intellectual life of a people traditionally zealous for education renders their example instructive for the younger institutions. With reference to the provision made by the newer universities for studies bearing on practical life, it should be remarked that much has been done in the same direction by the two older universities also. At Cambridge, for example, degrees can be taken in economics and associated branches of political science; in mechanism and applied mechanics, and in agricultural sciences. It certainly can not now be said that the old universities neglect studies which are of direct utility, though they rightly insist that the basis and method of such studies shall be liberal.

In looking back on the general course of this whole movement in England, we find that it has been steady, smooth and fairly rapid. It has not been due to any spasmodic impulse or artificial propaganda, but has been the result of natural forces operating throughout the nation. Universities, and the training which they give, have come to count for more in our national life as a whole. It should be noted in passing that the missionary movement known as university extension did not arise in the first instance from spontaneous academic action, but was a response to public appeals from without. It had its origin in memorials addressed to the University of Cambridge, in 1872, by various public bodies; and it was in compliance with those memorials that, in the winter of 1873, the first courses of extension lectures were organized in the Midlands. Another fact of vital significance in the movement is that it has included ample provision for the higher education of women.

With reference to the present position and prospects of the higher education in South Africa, I tried, before leaving England, to acquaint myself with at least the outlines of the general situation; but it is only with great diffidence that I shall offer a few observations bearing on some of the broader aspects of the question. I trust to be heard with indulgence by those from whom I shall hope to learn more. At any rate, I can truly say that the question seems to me one of the deepest interest and of the gravest importance. Indeed, it does not require much insight or imagination to apprehend the greatness of the issues that are involved.

In the first place, it would be correct, if I am not mistaken, to say that in South Africa at large there is a genuine and a keen desire for efficient education of the highest type. A sound liberal education is desired for all who can profit by it, whatever their future callings are to be. But the practical and immediate need for the organizing of the highest teaching is felt, I believe, more particularly in regard to three great professions—the profession of engineering, in all its branches; the profession of agriculture (including forestry); and the profession of education itself, on which the intellectual future of South Africa must so largely and directly depend. That the interest in the higher instruction is so real must be regarded as the best tribute to the efforts of those able and devoted men who, in various parts of this land, have labored with dauntless perseverance for the improvement of primary and secondary education. Unstinted gratitude is due also to the University of the Cape of Good Hope. It is acknowledged on all hands that the university, as the chief guardian of learning in South Africa, has done admirable work in maintaining a high standard of general education. Certainly it can not be regarded as any disparagement of that work if, as seems to be the case, a widespread desire exists that

South Africa should possess an institution, or institutions, of university rank, which, besides examining, should also teach. That is a natural progress, which is illustrated by the recent reconstitution of the London University itself. I am not qualified, nor should I desire, to discuss the various difficulties of detail which surround the question of a teaching university. That question is, for South Africa, an eminently practical one; and doubtless it will be solved, possibly at no distant time, by those who are most competent to deal with it. I will only venture to say a few words on some of the more general aspects of the matter.

The primary needs of daily life in a new country make demands for certain forms of higher training—demands which may be unable to wait for the development of anything so complex and costly as a teaching university. It is necessary to provide a training for men who shall be able to supervise the building of houses, the making of roads, bridges and railways, and to direct skilled labor in various useful arts and handicrafts. The first step in such a provision is to establish technical schools and institutes. Germany is, I suppose, the country where the educational possibilities of the technical school are realized in the amplest measure. In Germany the results of the highest education are systematically brought to bear on all the greater industries. But this highest education is not given only in completely equipped universities which confer degrees. It is largely given in the institutions known as technical high schools. In these schools teaching of a university standard is given, by professors of university rank, in subjects such as architecture, various branches of engineering, chemistry and general technical science. There are, I think, some ten or eleven of these technical high schools in Germany. In these institutions the teaching of the special art or science, on its theoretical side, is carried, I believe, to a point as high as could be attained in a university; while on the practical side it is carried beyond the point which in a university would usually be possible. In England we have nothing, I believe, which properly corresponds to the German technical high school; but we may expect to see some of the functions of such a school included among the functions of the new universities in our great industrial and commercial towns.

Now technical schools or institutes, which do not reach the level of a German technical high school, may, nevertheless, be so planned as to be capable of being further developed as parts of a great teaching university. And the point which I now wish to note is this—that the higher education given in a technical institute, which is only such, will not be quite the same as that given in the corresponding department of a teaching university. University education, as such, when it is efficient, has certain characteristics which differentiate it from the train-

ing of a specialist, however high the level of the teaching in the special subject may be. Here, however, I pause for a moment to guard against a possible misconception. I am not suggesting that the specialist training given in a technical institute, though limited, is not an excellent thing in itself; or that, in certain conditions and circumstances, it is not desirable to have such a training, attested by a diploma or certificate, instead of aiming at a university standard and a university degree. Universities themselves recognize this fact. They reserve their degrees for those who have had a university training; but they also grant diplomas for proficiency in certain special branches of knowledge. Cambridge, for instance, gives a diploma in the science and practise of agriculture; and the examinations for the diploma are open to persons who are not members of the university.

But the university training, whatever its subject, ought to give something which the purely specialist training does not give. What do we understand by a university education? What are its distinctive characteristics? The word *universitas,* as you know, is merely a general term for a corporation, specially applied in the middle ages to a body of persons associated for purposes of study, who, by becoming a corporation, acquired certain immunities and privileges. Though a particular university might be strongest in a particular faculty, as Bologna was in law and Paris in theology, yet it is a traditional attribute of such a body that several different branches of higher study shall be represented in it. It is among the distinctive advantages of a university that it brings together in one place students—by whom I mean teachers as well as learners—of various subjects. By doing this the university tends to produce a general breadth of intellectual interests and sympathies; it enables the specialist to acquire some sense of the relations between his own pursuit and other pursuits; he is helped to perceive the largeness of knowledge. But, besides bringing together students of various subjects, it is the business of a university to see that each subject shall be studied in such a manner as to afford some general discipline of the mental faculties. In his book on 'The Idea of a University' Newman says:

> This process of training, by which the intellect, instead of being formed or sacrificed to some particular or accidental purpose, some specific trade or profession, or study or science, is disciplined for its own sake, for the perception of its own proper object, and for its own highest culture, is called liberal education; and though there is no one in whom it is carried as far as is conceivable, or whose intellect would be a pattern of what intellects should be made, yet there is scarcely any one but may gain an idea of what real training is, and at least look towards it, and make its true scope and result, not something else, his standard of excellence; and numbers there are who may submit themselves to it and secure it to themselves in good measure. And to set forth the right standard, and to train according to it, and to help forward all students

towards it according to their various capacities, this I conceive to be the business of a university

It may be granted that the function of a university, as Newman here describes it, is not always realized; universities, like other human institutions, have their failures. But his words truly express the aim and tendency of the best university teaching. It belongs to the spirit of such teaching that it should nourish and sustain ideals; and a university can do nothing better for its sons than that; a vision of the ideal can guard monotony of work from becoming monotony of life. But there is yet another element of university training which must not be left out of account; it is, indeed, among the most vital of all. I mean that informal education which young men give to each other. Many of us, probably, in looking back on our undergraduate days, could say that the society of our contemporaries was not the least powerful of the educational influences which we experienced. The social life of the colleges at Oxford and Cambridge is a most essential part of the training received there. In considering the questions of the higher education in South Africa it is well to remember that the social intercourse of young students, under conditions such as a great residential university might provide, is an instrument of education which nothing else can replace. And it might be added that such social intercourse is also an excellent thing for the teachers.

The highest education, when it bears its proper fruit, gives not knowledge only, but mental culture. A man may be learned, and yet deficient in culture; that fact is implied by the word 'pedantry.' "Culture," said Huxley, "certainly means something quite different from learning or technical skill. It implies the possession of an ideal, and the habit of critically estimating the value of things by a theoretic standard." "It is the love of knowledge," says Henry Sidgwick, "the ardor of scientific curiosity, driving us continually to absorb new facts and ideas, to make them our own, and fit them into the living and growing system of our thought; and the trained faculty of doing this, the alert and supple intelligence exercised and continually developed in doing this—it is in these that culture essentially lies." And if this is what culture really means, evidently it can not be regarded as something superfine—as an intellectual luxury suited only for people who can lead lives of elegant leisure. Education consists in organizing the resources of the human being; it seeks to give him powers which shall fit him for his social and physical world. One mark of an uneducated person is that he is embarrassed by any situation to which he is not accustomed. The educated person is able to deal with circumstances in which he has never been placed before; he is so, because he has acquired general conceptions; his imagination, his judgment, his powers of intelligent sympathy, have been developed. The mental culture

which includes such attributes is of inestimable value in the practical work of life, and especially in work of a pioneer kind. It is precisely in a country which presents new problems, where novel difficulties of all sorts have to be faced, where social and political questions assume complex forms for which experience furnishes no exact parallel, it is precisely there that the largest and best gifts which the higher education can confer are most urgently demanded.

But how is culture, as distinct from mere knowledge, to be attained? The question arises as soon as we turn from the machinery of the higher education to consider its essence, and the general aims which it has in view. Culture can not be secured by planning courses of study, nor can it be adequately tested by the most ingenious system of examinations. But it would be generally allowed that a university training, if it is really successful, ought to result in giving culture, over and above such knowledge as the student may acquire in his particular branch or branches of study. We all know what Matthew Arnold did, a generation ago, to interpret and diffuse in England his conception of culture. The charm, the humor and also the earnestness of the essays in which he pleaded that cause render them permanently attractive in themselves, while at the same time they have the historical interest of marking a phase in the progress of English thought and feeling about education. For, indeed, whatever may be the criticisms to which Arnold's treatment of the subject is open in detail, he truly indicated a great national defect; and by leading a multitude of educated persons to realize it, he helped to prepare the way for better things. Dealing with England as it was in the sixties, he complained that the bulk of the well-to-do classes were devoid of mental culture—crude in their perceptions, insensible to beauty, and complacently impenetrable to ideas. If, during the last thirty or forty years, there has been a marked improvement, the popular influence of Matthew Arnold's writings may fairly be numbered among the contributory causes, though other and much more potent causes have also been at work. When we examine Arnold's own conception of culture, as expressed in successive essays, we find that it goes through a process of evolution. At first he means by 'culture' a knowledge and love of the best literature, ancient and modern, and the influence on mind and manners which flows thence. Then his conception of culture becomes enlarged; it is now no longer solely or mainly esthetic, but also intellectual; it includes receptivity of new ideas; it is even the passion for 'seeing things as they really are.' But there is yet a further development. True culture, in his final view, is not only esthetic and intellectual; it is also moral and spiritual; its aim is, in his phrase, 'the harmonious expansion of all the powers which made the beauty and worth of human nature.' But whether the scope which Arnold, at a

particular moment, assigned to culture was narrower or wider, the instrument of culture with which he was chiefly concerned was always literature. Culture requires us, he said, to know ourselves and the world; and, as a means to this end, we must 'know the best that has been thought and said in the world.' By literature, then—as he once said in reply to Huxley—he did not mean merely *belles lettres;* he included the books which record the great results of science. But he insisted mainly on the best poetry and the highest eloquence. In comparing science and literature as general instruments of education, Arnold observed that the power of intellect and knowledge is not the only one that goes to the building up of human life; there is also the power of conduct and the power of beauty. Literature, he said, serves to bring knowledge into relation with our sense for conduct and our sense for beauty. The greater and more fruitful is the progress of science, the greater is the need for humane letters, to establish and maintain a harmony between the new knowledge and those profound, unchanging instincts of our nature.

It is not surprising that, in the last third of the nineteenth century, Arnold's fascinating advocacy of literature, as the paramount agency of culture, should have incurred some criticism from the standpoint of science and of philosophy. The general drift of this criticism was that the claim which he made for literature, though just in many respects, was carried too far; and also that his conception of intellectual culture was inadequate. As a representative of such criticism, I would take the eminent philosopher whose own definition of culture has already been cited, Henry Sidgwick: for no one, I think, could put more incisively the particular point with which we are here concerned. "Matthew Arnold's method of seeking truth," says Sidgwick, "is a survival from a prescientific age. He is a man of letters pure and simple; and often seems quite serenely unconscious of the intellectual limitations of his type." The critic proceeds to enumerate some things which, as he affirms, are 'quite alien to the habitual thought of a mere man of letters.' They are such as these: "How the crude matter of common experience is reduced to the order and system which constitutes it an object of scientific knowledge; how the precisest possible conceptions are applied in the exact apprehension and analysis of facts, and how by facts thus established and analyzed the conceptions in their turn are gradually rectified; how the laws of nature are ascertained by the combined processes of induction and deduction, provisional assumption and careful verification; how a general hypothesis is used to guide inquiry, and, after due comparison with ascertained particulars, becomes an accepted theory; and how a theory, receiving further confirmation, takes its place finally as an organic part of a vast, living, ever-growing system of knowledge." Sidgwick's conclusion is as fol-

lows: "Intellectual culture, at the end of the nineteenth century, must include as its most essential element a scientific habit of mind; and a scientific habit of mind can only be acquired by the methodical study of some part at least of what the human race has come scientifically to know."

There is nothing in that statement to which exception need be taken by the firmest believer in the value of literary education. The more serious and methodical studies of literature demand, in some measure, a scientific habit of mind, in the largest sense of that expression; such a habit is necessary, for instance, in the study of history, in the scientific study of language and in the 'higher criticism.' Nor, again, does any one question that the studies of the natural sciences are instruments of intellectual culture of the highest order. The powers of observation and of reasoning are thereby disciplined in manifold ways; and the scientific habit of mind so formed is in itself an education. To define and describe the modes in which that discipline operates on the mind is a task for the man of science; it could not, of course, be attempted by any one whose own training has been wholly literary. But there is one fact which may be noted by any intelligent observer. Many of our most eminent teachers of science, and more especially of science in its technical applications, insist on a demand which, in the provinces of science, is analogous to a demand made in the province of literary study by those who wish such study to be a true instrument of culture. As the latter desire that literature should be a means of educating the student's intelligence and sympathies, so that teachers of science, whether pure or applied, insist on the necessity of cultivating the scientific imagination, of developing a power of initiative in the learner, and of drawing out his inventive faculties. They urge that, in the interests of the technical industries themselves, the great need is for a training which shall be more than technical—which shall be thoroughly scientific. Wherever scientific and technical education attains its highest forms in institutions of university rank, the aim is not merely to form skilled craftsmen, but to produce men who can contribute to the advance of their respective sciences and arts, men who can originate and invent. There is a vast world-competition in scientific progress, on which industrial and commercial progress must ultimately depend; and it is of national importance for every country that it should have men who are not merely expert in things already known, but who can take their places in the forefront of the onward march.

But meanwhile the claims of literary culture, as part of the general higher education, must not be neglected or undervalued. It may be that, in the prescientific age, those claims were occasionally stated in a somewhat exaggerated or one-sided manner. But it remains as true as ever that literary studies form an indispensable element of a really

liberal education. And the educational value of good literature is all the greater in our day, because the progress of knowledge more and more enforces early specialization. Good literature tends to preserve the breadth and variety of intellectual interests. It also tends to cultivate the sympathies; it exerts a humanizing influence by the clear and beautiful expression of noble thoughts and sentiments; by the contemplation of great actions and great characters; by following the varied development of human life, not only as an evolution governed by certain laws, but also as a drama full of interests which intimately concern us. Moreover, as has well been said, if literature be viewed as one of the fine arts, it is found to be the most altruistic of them all, since it can educate a sensibility for other forms of beauty besides its own. The genius of a Ruskin can quicken our feeling for masterpieces of architecture, sculpture and painting. Even a very limited study of literature, if it be only of the right quality, may provide permanent springs of refreshment for those whose principal studies and occupations are other than literary. We may recall here some weighty words written by one of the very greatest of modern men of science. "If I had to live my life again," said Charles Darwin, "I would have made it a rule to read some poetry and listen to some music at least once every week. . . . The loss of these tastes is a loss of happiness, and may possibly be injurious to the intellect, and more probably to the moral character, by enfeebling the emotional part of our nature." The same lesson is enforced by John Stuart Mill, in that remarkable passage of his 'Autobiography' where he describes how, while still a youth, he became aware of a serious defect, a great lacuna, in that severe intellectual training which, for him, had commenced in childhood. It was a training from which the influences of imaginative literature had been rigidly excluded. He turned to that literature for mental relief, and found what he wanted in the poetry of Wordsworth. "I had now learned by experience"—this is his comment—"that the passive susceptibilities needed to be cultivated as well as the active capacities, and required to be nourished and enriched as well as guided." Nor is it merely to the happiness and mental well-being of the individual that literature can minister. By rendering his intelligence more flexible, by deepening his humanity, by increasing his power of comprehending others, by fostering worthy ideals; it will add something to his capacity for cooperating with his fellows in every station of life and in every phase of action; it will make him a better citizen, and not only a more sympathetic, but also a more efficient member of society.

One of the urgent problems of the higher education in our day is how to secure an adequate measure of literary culture to those students whose primary concern is with scientific and technical pursuits. Some of the younger English universities, which give degrees in science, con-

tribute to this purpose by providing certain options in the science curriculum; that is, a given number of scientific subjects being prescribed for study with a view to the degree of B.Sc., the candidate is allowed to substitute for one of these a subject taken from the arts curriculum, such, for instance, as the theory and practise of education. This is the case in the University of Wales and in the University of Birmingham; and there are indications, I believe, that this example will be followed elsewhere. Considering how hard and sustained is the work exacted from students of science, pure or applied, it seems important that the subjects from which they are to derive their literary culture should be presented to them, not in a dry-as-dust fashion, not chiefly as subjects of examination, but rather as sources of recreation and changes of mental activity. From this point of view, for British students of science the best literature of the English language offers unequaled advantages. It may be mentioned that the board of education in London is giving particular attention to the place which English literature should hold in the examination of students at the training colleges, and has under consideration carefully planned courses of study, in which portions of the best English writers of prose and of verse are prescribed to be read in connection with corresponding periods of English history, it being understood that the study of the literature shall be directed, not to philological or grammatical detail, but to the substance and meaning of the books, and to the leading characteristics of each writer's style. If, on the other hand, the student is to derive his literary culture, wholly or in part, from a foreign literature, ancient or modern, then it will be most desirable that, before leaving school, he should have surmounted the initial difficulties of grammar, and should have learned to read the foreign language with tolerable ease.

When we look at this problem—how to combine the scientific and the literary elements of culture—in the light of existing or prospective conditions in South Africa, it appears natural to suppose that, in a teaching university, the faculty of education would be that with which literary studies would be more particularly connected. And if students of practical sciences, such as engineering and agriculture, were brought together at the same center where the faculty of education had its seat, then it should not be difficult, without unduly trenching on the time demanded by scientific or technical studies, to provide such students with facilities for some measure of good literary training.

A further subject is necessarily suggested by that with which we have been dealing—I mean the relation of university to secondary education; but on that I can only touch very briefly. Before university education can be widely efficient, it is indispensable that secondary education should be fairly well developed and organized. Secondary education should be intelligent—liberal in spirit—not too much tram-

meled by the somewhat mechanical uniformity apt to result from working for external examinations, but sufficiently elastic to allow for different aptitudes in the pupils, and to afford scope for the free initiative of able teachers. It is a gain for the continuity of education when a school-leaving examination can be accepted as giving admission to the university. Such an examination must be conducted under the authority of the university; but there is much to be said in favor of the view that, under proper safeguards, the school-teachers should have a part in the examination; always provided that the ultimate control, and the decision in all cases of doubt, shall rest with the university. A system of school-leaving examinations for this country was earnestly advocated, I believe, by Mr. P. A. Barnett, who has achieved such excellent work for the cause of education in Natal. To discuss the advantages or difficulties of such a proposal, as they at present affect South Africa, would demand knowledge which I do not possess; and I must content myself with the expression of a hope that in days to come—perhaps in a not distant future—it may be found practicable to form such a link between the highest education and the grade next below it.

But the limit of time proper for a chairman's address has now almost been reached. I thank you sincerely for the kindness and patience with which you have heard me. In conclusion, I would only say how entirely I share a conviction which has been expressed by one to whose ability, to whose generous enthusiasm and unflagging efforts the cause of education in this country owes an incalculable debt—I refer to Mr. E. B. Sargant. Like him, I believe that the progress of education in all its grades, from the lowest to the highest, is the agency which, more surely than any other, will conduce to the prosperity and the unity of South Africa. For all workers in that great cause it must be an inspiring thought that they are engaged in promoting the most fundamental and the most far-reaching of national interests. They are endeavoring to secure that the men and women to whom the future of this country belongs shall be equal to their responsibilities and worthy of their inheritance. In that endeavor the sympathies which they carry with them are world-wide. As we come to see, more and more clearly, that the highest education is not only a national but an imperial concern, there is a growing desire for interchange of counsels and for active cooperation between the educational institutions of the colonies and those of the mother country. The development of education in South Africa will command keen attention, and will be followed by earnest good wishes, not only in England, but throughout the British dominions. One of the ideas which are bound up with the history and the traditions of our English public schools and universities is the idea of efficient work for the state. Those institutions have been largely

molded, from generation to generation, by the aim of ensuring a supply of men qualified to bear a worthy part, either in the government of the nation, or in professional activities which are indispensable to the national welfare. In our own time, and more especially within the last thirty years, one particular aspect of that idea is illustrated by the closer connections which have been formed between the universities and the higher branches of the civil service. The conception of work for the commonweal is in its turn inseparable from loyalty to those ideals of character and conduct by which English life and public policy have been built up. It is by the long and gradual training which such ideals have given that our race has been fitted to grapple with responsibilities which have inevitably grown, both in extent and in complexity, far beyond anything of which our forefathers could have dreamed. That training tends also to national self-knowledge; it makes for a sober estimate of our national qualities and defects; it quickens a national sense of duty to our neighbor. The munificence of a far-sighted statesman has provided that selected youths, whose homes are in this land, and whose life-work may be here, shall go for a while to England, shall breathe the intellectual and social atmosphere of a great English university, and shall learn to judge for themselves of the sources from which the best English traditions have flowed. That is excellent. But it is also most desirable that those traditions should pass as living forces into the higher teaching of South Africa itself, and that their spirit should animate educational institutions whose special forms have been molded by local requirements. That, indeed, has been, and is, the fervent wish of men whose labors for South African education have already borne abundant fruit, and are destined to bear yet larger fruit in the future. May those labors prosper, and may that wish be fulfilled! The sooner will come the day when the inhabitants of this country, this country of vast and still indefinite possibilities, will be able to feel, in a sense higher and deeper than citizens of the Roman Empire could conceive, *Cuncti gens una sumus* ('We are all one people'). If the work which lies before us, in this section of the British Association, should result in contributing anything towards the promotion of those great objects, by helping to elucidate the conditions of further progress, our deliberations will not have been held in vain.

THE CATTLE PROBLEM OF ARCHIMEDES.

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THE sleepy town of Wolfenbüttel in northern Germany is the proud possessor of a library containing about 240,000 books and 10,000 manuscripts, many of the latter being Greek and Latin writings of interest and value. Lessing, the poet and philosopher, was appointed its librarian in 1769, and a few years later he published translations of some of the unique manuscripts with commentaries thereon. One of these was a Greek poem of forty-four lines which states an arithmetical problem that has since attracted much attention on account of the difficulty of its solution and the enormous numbers required to fulfil its conditions. The name of Archimedes appears in the title of the poem, it being said that he sent it in a letter to Eratosthenes, the Cyrean, to be investigated by the mathematicians of Alexandria. Opinions differ as to the truth of this statement, and it may well be doubted if Archimedes was the real author, particularly as no mention of the problem has been found in the writings of the Greek mathematicians.

The following statement of the cattle problem has been abridged from the German translations published by Nesselmann in 1842, and by Krumbiegel in 1880:

Compute, O friend, the number of the cattle of the sun which once grazed upon the plains of Sicily, divided according to color into four herds, one milk-white, one black, one dappled and one yellow. The number of bulls is greater than the number of cows, and the relations between them are as follows:

White bulls $= (\frac{1}{2} + \frac{1}{3})$ black bulls + yellow bulls,
Black bulls $= (\frac{1}{4} + \frac{1}{5})$ dappled bulls + yellow bulls,
Dappled bulls $= (\frac{1}{6} + \frac{1}{7})$ white bulls + yellow bulls,
White cows $= (\frac{1}{3} + \frac{1}{4})$ black herd,
Black cows $= (\frac{1}{4} + \frac{1}{5})$ dappled herd,
Dappled cows $= (\frac{1}{5} + \frac{1}{6})$ yellow herd,
Yellow cows $= (\frac{1}{6} + \frac{1}{7})$ white herd.

If thou canst give, O friend, the number of each kind of bulls and cows, thou art no novice in numbers, yet can not be regarded as of high skill. Consider, however, the following additional relations between the bulls of the sun:

White bulls + black bulls = a square number,
Dappled bulls + yellow bulls = a triangular number.

If thou hast computed these also, O friend, and found the total number of cattle, then exult as a conqueror, for thou hast proved thyself most skilled in numbers.

The Wolfenbüttel manuscript has an appendix, also in Greek, giving numbers in answer to the problem, the total number of cattle being stated as 4,031,126,560, but the results satisfy only the first seven conditions. Lessing also gives results computed by Leiste, a clergyman of Wolfenbüttel, whose solution satisfies these seven conditions and likewise the eighth one. In 1821 J. and K. L. Struve published a critical and mathematical discussion, which was followed in 1828 by another from G. Hermann. The latter makes the interesting remark that Gauss had arrived at a complete solution; but, if so, no further information regarding it has been obtained. Many other attempts at solution were made, but the large numbers required to satisfy the nine conditions discouraged many investigators. Some critics thought that the original problem of Archimedes included only the first seven conditions and that the two others had been added by a later writer. It is, of course, clearly seen that the exercise as stated includes two problems, the first to find integral numbers that satisfy the first seven conditions, and the second to find integral numbers that satisfy all the nine conditions. As the poem says, the first problem may be solved by those of moderate proficiency in numbers, while the second can only be done by those of the highest skill.

The first problem is an easy one for a boy in the high school. Let W, B, D, Y represent the number of white, black, dappled and yellow bulls and let w, b, d, y represent the number of white, black, dappled and yellow cows. The seven conditions then give the seven equations:

$$W = \tfrac{5}{6} B + Y, \quad (1) \qquad w = \tfrac{7}{12} (B + b), \quad (4)$$

$$B = \tfrac{9}{20} D + Y, \quad (2) \qquad b = \tfrac{9}{20} (D + d), \quad (5)$$

$$D = \tfrac{13}{42} W + Y, \quad (3) \qquad d = \tfrac{11}{30} (Y + y), \quad (6)$$

$$y = \tfrac{13}{42} (W + w), \quad (7)$$

and these contain eight unknown quantities. The problem, therefore, is of the kind called indeterminate, for many sets of numbers may be found to satisfy the seven equations. That set having the smallest numbers is the one required, for any other set may be found by multiplying these numbers by the same integer. If B and W are eliminated from equations (1), (2), (3), there will be found the single equation $891\ D = 1{,}580\ Y$, and hence $Y = 891$ and $D = 1{,}580$ are the smallest integral numbers satisfying it; from these are found $B = 1{,}602$ and $W = 2{,}226$. These values, before insertion in equations (4) to (7), are to be multiplied by a factor m, the value of which is later to be determined, so that the number of cows in each herd shall be an integer. Proceeding with the elimination, the values of w, b, d, y are deduced in terms of m, and it is then seen that 4,657 is the least value of m which will make the results integers. It is thus easily found that

$B = 7{,}460{,}514$, $b = 4{,}893{,}246$,
$W = 10{,}366{,}482$, $w = 7{,}206{,}360$,
$D = 7{,}358{,}060$, $d = 3{,}515{,}820$,
$Y = 4{,}149{,}387$, $y = 5{,}439{,}213$,

are the least numbers satisfying the conditions of the first problem. The total number of cattle is 50,389,082, not too great to graze upon the island Sicily, the area of which is about 7,000,000 acres. If the above numbers are multiplied by 80 they give the results stated in the appendix to the Wolfenbüttel manuscript.

The second or complete problem includes the determination of numbers which satisfy not only equations (1) to (7), but also

$$W + B = \text{a square number}, \quad (8)$$
$$D + Y = \text{a triangular number}, \quad (9)$$

and this is to be done by finding an integer N to multiply into each of the results of the first problem. Since $W + B$ is 17,826,996 and $D + Y$ is 11,507,447, these equations become

$$17{,}826{,}996\,N = \text{a square number},$$
$$11{,}507{,}447\,N = \text{a triangular number}.$$

A number N that will satisfy one of these conditions can be found without difficulty, but to determine one that will satisfy both is a task requiring an enormous amount of labor and patience. In fact, this required number N has never been completely computed.

It has been claimed by some critics that the ninth condition should be rejected altogether, for they asserted that there is no evidence that Archimedes or the Greek mathematicians had the idea of a triangular number. On this hypothesis the solution is easy. Since $W + B$ is 17,826,966 N or $4 \times 4{,}456{,}749\ N$, and since 4,456,749 contains no number that is a perfect square, it is plain that N must be 4,456,749. Accordingly, each of the numbers found in the first solution must be multiplied by 4,456,749 in order to satisfy equations (1) to (8) inclusive; the number $W + B$ is then 79,450,446,596,004, which is a perfect square, but the number $D + Y$ is 51,285,802,909,803, which is not a triangular number. This solution is identical with that of Leiste as published by Lessing in 1773.

For the benefit of those who are neither novices nor of high skill in numbers, it is now time to explain what is meant by a triangular number. The number 10 is triangular because ten dots can be arranged in rows in the form of a triangle, there being one dot in the first row, two in the second, three in the third and four in the fourth. The next higher triangular number is 15 and the next 21, and in general $\frac{1}{2}n(n+1)$ is a triangular number whenever n is an integer, n being the number of rows parallel to one side of the triangle. The proof that 51,285,802,909,803 is not a triangular number consists in

equating it to $\frac{1}{2}n(n+1)$ and computing the value of n by the solution of the quadratic equation; this value of n is found to be not an integer.

Some mathematicians who desired to solve the cattle problem have claimed that $W+B$ is not required to be a perfect square, because the statement of the eighth condition in the Greek manuscript does not use the term square number, but mentions 'a square figure.' Since the length of a bovine animal is greater than its breadth, it was maintained by Wurm, about 1830, that $W+B$ is required to be a rectangular number, that is, a number having two factors. On this hypothesis he made a solution which gave the total number of cattle as 5,916,837,175,686, and the number of white and black bulls as 2,093,299,351,328, which has the factors 704,538 $\times$ 2,971,166, as well as many others, while the number of dappled and yellow bulls is 1,351,238,949,081, which is a triangular number, so that these bulls could be arranged in a triangle with 3,287,843 rows.

The consensus of opinion regarding the eighth and ninth conditions is expressed, however, in the statement of the problem as given above, namely, that the terms 'square figure' and 'triangular figure' should be understood to mean square number and triangular number. Since 51,285,802,909,803 is the number of dappled and yellow bulls which results from a solution that satisfies conditions (1) to (8) inclusive, it is plain that the ninth condition may be expressed by

$$51{,}285{,}802{,}909{,}803,\ x^2 = \tfrac{1}{2}\,n\,(n+1),$$

in which x and n are to be integers. When x^2 has been found, each of the numbers of the first solution is to be multiplied by 4,456,749 x^2, in order to give the number of bulls and cows in each herd, satisfying the nine imposed conditions.

These numbers were readily seen to be so great that the island of Sicily could not contain all the cattle, as the problem seems to demand. This requirement, however, was understood to be only figurative, and mathematicians agreed that the numbers, though very large, could be found, but that no useful purpose would be attained by computing them. Thus the question rested until 1880, when Amthor undertook to determine how many figures were required to express one of the numbers. His lengthy investigation demonstrates that 206,545 figures are needed to express the total number of cattle. He further computed that 766 are the first three figures of this number, so that $766 \times 10^{206{,}542}$ is the approximate number of cattle. This is an enormous number, and it is easy to show that a sphere having the diameter of the milky way, across which light takes ten thousand years to travel, could contain only a part of this great number of animals, even if the size of each is that of the smallest bacterium.

It would be thought that, after this investigation by Amthor, the question of solving the cattle problem would have been finally dropped, but such was not the case. The certainty that numbers could be found satisfying all nine conditions existed, and until they had been actually computed the challenge of the author of the problem still remained open. The way to solve it was well understood from the theory of indeterminate analysis. Let the preceding equation be multiplied by 8 and unity added to each member, and let $2n + 1$ be called y; then it reduces to

$$y^2 - 410{,}286{,}423{,}278{,}424\, x^2 = 1$$

which is of the form $y^2 - Ax^2 = 1$, and it is known that when A is an integer there can always be found integral values of y and x which satisfy the equation. The method of obtaining such values of x and y can not well be explained here, but such a method was devised many years ago by Pell and by Fermat, and it is well known to those skilled in higher arithmetic. For example, take the simple case where $A = 19$, or $y^2 - 19\,x^2 = 1$, then the smallest integral values of y and x which satisfy this equation may be found to be 170 and 39, so that the square of 170 minus 19 times the square of 39 equals unity.

In 1889 A. H. Bell, a surveyor and civil engineer of Hillsboro, Illinois, began the work of solution. He formed the Hillsboro Mathematical Club, consisting of Edmund Fish, George H. Richards and himself, and nearly four years were spent on the work. They computed thirty of the left-hand figures and twelve of the right-hand figures of the value of x^2 without finding the intermediate ones. This value is

$$x^2 = 34{,}555{,}906{,}354{,}559{,}370\ldots\ldots\ldots\ldots 252{,}058{,}980{,}100$$

in which the dots indicate fifteen computed figures which it is here unnecessary to give and 206,487 uncomputed ones; the total number of figures in this number is 206,531. The final step is to multiply each of the numbers of the first solution by 4,456,749 and by this value of x^2, and thus are obtained

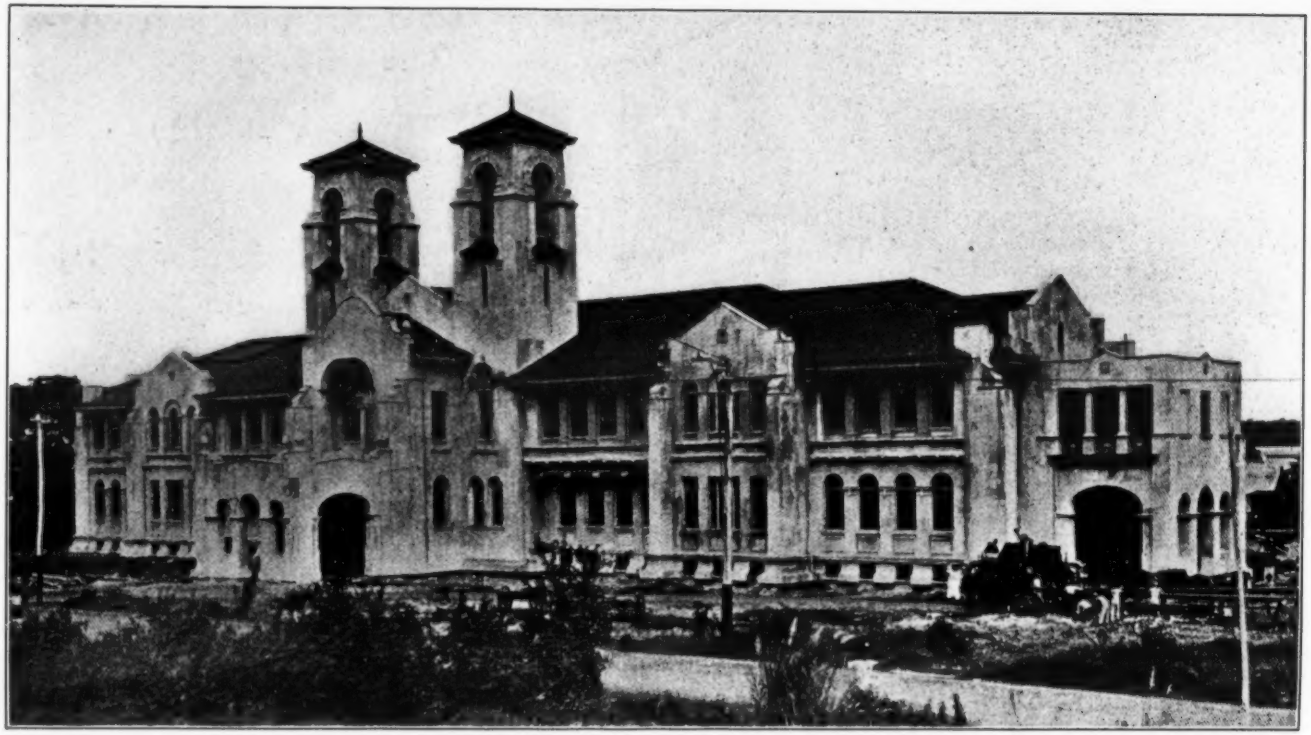
White bulls	= 1,596,510	 341,800
Black bulls	= 1,148,971	 178,600
Dappled bulls	= 1,133,192	 894,000
Yellow bulls	= 639,034	 026,300
White cows	= 1,109,829	 564,000
Black cows	= 735,594	 645,400
Dappled cows	= 541,460	 318,000
Yellow cows	= 837.676	 113,700
Total cattle	7,760,271	 081,800

in which the dots represent 206,532 figures, the total number of figures in each line being either 206,545 or 206,544. In each of these lines there are omitted twenty-four figures at the left-end and six at the

right-end which were computed by the Hillsboro Mathematical Club.

This solution is published in the *American Mathematical Magazine* for May, 1895, where Bell remarks that each of these enormous numbers is 'one half mile long.' A clearer idea of its length may be obtained from considering the space it would take to print it. Each page of this MONTHLY contains 45 lines and in each line about 50 figures may be set, so that one page would permit a number of about 2,250 figures to be printed. To print a number containing 206,545 figures there would be required 92 pages, and to print the nine numbers indicated above a volume of about 830 large octavo pages in this size of page and type would be needed.

It is known that Archimedes speculated regarding large numbers, for his book called Arenarius is devoted to showing that a number may be written that will express the number of grains of sand in a sphere of the size of the earth. It can not be proved that Archimedes was, or was not, the author of the cattle problem, but, as Amthor remarks, the enormous numbers required in its solution render it worthy of his genius and proper to bear his name. Its closing challenge still remains open, for the complete solution has not yet been made. Moreover, it is practically impossible that the long numbers can ever be computed, since the investigations of Bell show that this would require the work of a thousand men for thousand years. The little prairie town of Hillsboro may, however, well exult as a conqueror, for its mathematical club has made the most complete of all solutions of the cattle problem and has proved itself to be highly skilled in numbers.



BUILDING OF THE BUREAU OF GOVERNMENT LABORATORIES, MANILA.

THE PROGRESS OF SCIENCE.

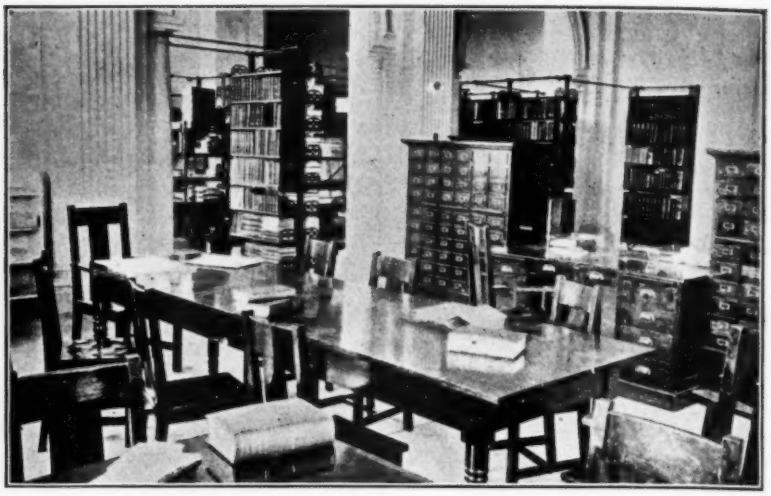
SCIENTIFIC WORK IN THE PHILIPPINE ISLANDS.

THE civil government of the Philippine Islands has been prompt in recognizing the importance of scientific work. The commission established in 1901 a Bureau of Government Laboratories and authorized the preparation of plans for a suitable building for the installation of biological and chemical laboratories. The commission was fortunate in securing as superintendent Dr. Paul C. Freer, professor of chemistry in the University of Michigan, under whose able direction the work has been organized and a building erected.

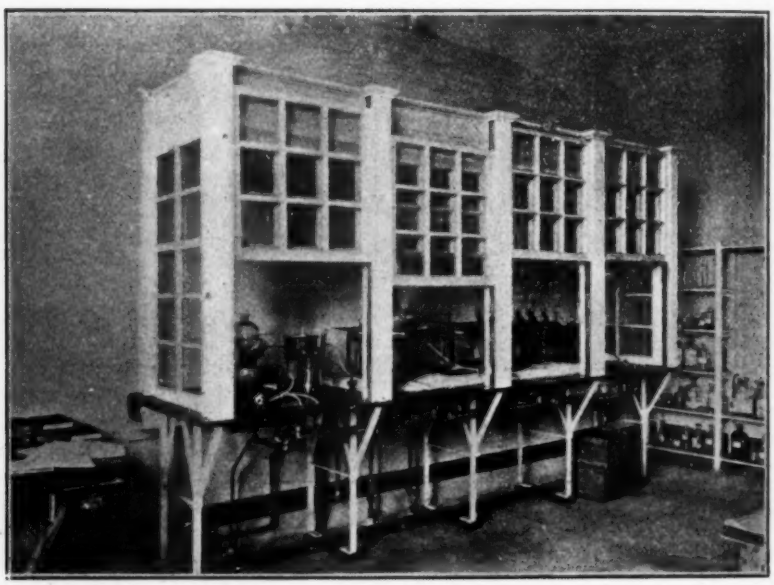
The illustration shows the building, which was designed with the assistance of the chief of the Insular Bureau of Architecture, Mr. E. K. Bourne, and is of pleasing and suitable architecture. In laboratory construction a low building has many advantages, and in the Philippine Islands the danger from earthquakes must be taken into consideration. In a tropical country coolness and ventilation are of great importance. Corridors, ten feet wide, run the entire length of the building, and as these are open at both ends a breeze usually passes through them. The laboratories are comparatively small rooms opening from the corridors. The building is divided into two symmetrical parts, the east half being used for biological and the west half for chemical work, with a library in the center. The power house has been placed in the rear, and in it is a serum laboratory. In addition to heat and electric power there are gas generators, compressed air, vacuum pumps and a refrigerating machine. The separate laboratories are provided with these conveniences for research and are well equipped with apparatus. The collection includes fifteen microscopes of the best Zeiss pattern, five Schanze microtomes and two Minot microtomes, incubators, balances, electrical furnaces and the like. The equipment is of special importance, as it takes at least seven months to procure new supplies from Europe or America. The library contains some 12,000 volumes and seventy sets of publications, and these again are essential where there is no access to large libraries.

The work done in the laboratories appears to be of much scientific value, twenty-two publications having been issued by members of the staff. It is, however, naturally difficult to secure scientific workers in distant and tropical regions unless they are attracted by the special problems that can only be solved there. The director of the laboratories hopes that facilities may be given similar, for example, to those at the Naples station, which will attract scientific workers to the islands. He also thinks it possible that the laboratories may be supported by gifts from those who are interested in the development of the islands or in the special problems that can only there be undertaken.

In addition to the scientific work undertaken by the Philippine government, the president of the United States has recommended that a scientific survey of the Islands be undertaken at the expense of the federal government. At his request the National Academy of Sciences appointed a committee to report on the desirability of instituting scientific explorations of the Islands, and this report was transmitted to the last congress



LIBRARY, SHOWING ONE OF THE READING TABLES.



ONE OF THE LARGER HOODS IN THE CHEMICAL LABORATORY.

by the president, with the recommendation that provision be made for the appointment of a board of surveys to superintend national surveys and explorations in the islands. This board would consist of representatives of the Coast and Geodetic Survey, the Geological Survey, the Biological Survey, the Division of Botany, the Forest Service, the Bureau of Fisheries and the Bureau of American Ethnology. The president urges that while these surveys would be beneficial to the inhabitants of the Philippine Islands, they should be undertaken as a national work valuable for the people of this country and of the world. It is to be hoped that congress will find time to take up this measure at the approaching session.

THE RUMFORD FUND.

THE American Academy of Arts and Sciences has published a pamphlet regarding the Rumford Fund administered by it which contains some facts of general scientific interest. Benjamin Thompson, who was created a count by Prince Maximilian of Bavaria and who chose to be called Count Rumford after a New Hampshire town from which the family of his wife had come, was born in Massachusetts in 1753 and died in France in 1814. He founded the Royal Institution of Great Britain in 1799, and by a bequest established the Rumford professorship for the application of science to the useful arts at Harvard University. In 1796 he gave to the Royal Society of Great Britain and to the American Academy of Arts and Sciences of Boston the sum of $5,000, the income of which in each case was to be given once every second year to the author of the most important discovery or useful improvement made during the preceding two years in heat or in light. The premium was to take the form of medals. An illustration of the medal awarded by the American Academy is here reproduced.

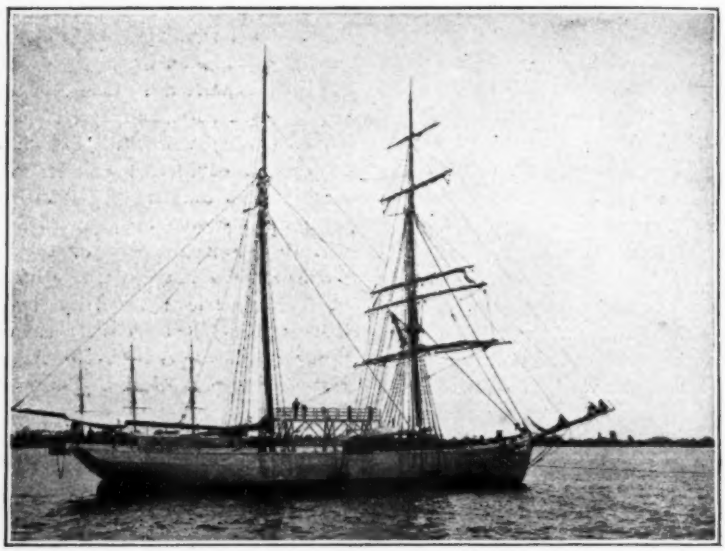
The Royal Society made the first award from the fund of Count Rumford himself in 1802; and every second year since, with the exception of several years, the medal has been awarded. The list of those on whom the premium has been conferred by the Royal Society is an illustrious series of men of science closing with Professor Ernest Rutherford, of McGill University, on whom it was conferred in 1904. The Royal Society was not limited in regard to the nationality of those on whom the premium could be conferred, but the American Academy by the terms of the gift could only confer it on authors on the continent of America or the American Islands. It appears that for many years there was no claimant whose merit was such in the opinion of the academy as to justify the award, and the fund accumulated to the amount of $20,000, when in 1831 application was made to the Supreme Court of Massachusetts for relief. It was ordered that in addition to the

THE RUMFORD MEDAL OF THE AMERICAN ACADEMY OF ARTS AND SCIENCES.

medals of the value of $300 which might be awarded every second year, the residue of the income could be used for the purchase of books and apparatus, for publications or for assisting investigation.

The first award of the Rumford premium of the Academy was made in 1839 to Robert Hare, of Philadelphia, for his oxyhydrogen-blowpipe, and the second was awarded in 1862 to John Ericsson for his caloric engine. Since that time the award has been made with tolerable regularity, the last awards having been made in 1902 to Professor George E. Hale for the spectroheliograph and in 1904 to Professor E. F. Nichols for his researches on radiation. The surplus income of the Rumford fund was at first awarded chiefly to the Harvard College Observatory and to other departments of Harvard University. The awards this year have been for researches as follows: Professor D. B. Brace, whose untimely death occurred this month, 'Double Refraction in Gases in an Electrical Field'; Charles B. Thwing, 'Thermo-electric Force of Metals and Alloys'; Harry W. Morse, 'Fluorescence'; John Trowbridge, 'Electric Double Refraction of Light'; Edwin H. Hall, 'Thermal and Thermo-electric Properties of Iron and Other Metals.'

The Rumford fund now amounts to nearly $60,000, and is administered by a standing committee of the American Academy. Applications for aid in the furtherance of research on light and heat may be made to the chairman of the committee, Professor Charles R. Cross, in care of the American Academy of Arts and Sciences, Boston, Mass.



THE *Galilee* IN SAN DIEGO HARBOR.

THE MAGNETIC SURVEY OF THE NORTH PACIFIC OCEAN.

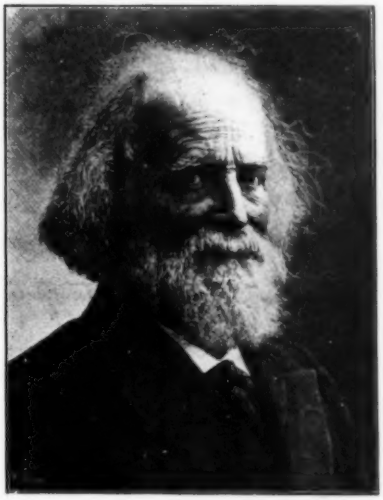
THE CARNEGIE INSTITUTION of Washington has made an appropriation of $20,000 to cover the expenses for the current year of a Magnetic Survey of the North Pacific Ocean, to be made by its Department of Terrestrial Magnetism of which Dr. L. A. Bauer is the director. For this purpose a wood-built, non-metallic sailing vessel of

about 600 tons displacement, *The Galilee*, has been chartered at San Francisco. The scientific personnel at present consists of Mr. J. F. Pratt, commander; Dr. J. Hobart Egbert, surgeon and magnetic observer; Mr. J. P. Ault, magnetic observer, and Mr. P. C. Whitney, magnetic observer and watch officer. The sailing master is Captain J. T. Hayes.

Trial trips were made early in August under the direction of Dr. Bauer, and the ship set sail on September 1 for the Hawaiian Islands. After its return, it will depart early in 1906 for a more lengthy cruise, embracing nearly the entire circuit of the North Pacific Ocean. The total length of the course marked out is about 70,000 knots. It is not supposed that great irregularity in the distribution of the earth's magnetism will be found over the deep waters of the Pacific, but distortions are likely to occur along the coast and in the neighborhood of islands. Thus, as Dr. Bauer has pointed out, with the aid of the results of the detailed magnetic survey of the United States and Alaska, opportunity will be afforded of studying the effect of the configuration of land and water on the distribution of the magnetic forces. The first circuit, passing as it does along the American and Asiatic coasts, will yield especially interesting results in this respect. Along the Aleutian Islands marked local disturbances will probably be disclosed, as reports are received frequently from mariners in this region regarding the unsatisfactory behavior of the compass.

ELISÉE RECLUS.

M. Elisée Reclus, who died near Bruges, on July 4, in his seventy-sixth year, was an eminent geographer and an interesting personality. He was the son of a protestant pastor, one of a family of twelve children, several of whom have become eminent. The revolutionary spirit which he showed all through his life may have been responsible for his geographical work, for it was after he was expelled from France in 1851 that he spent six years in continuous travel. Reclus returned to Paris in 1857 and wrote numerous geographical articles and books, including the volumes that have been translated into English under the title 'The Earth.' During the siege of Paris, he took the side of the communists, though among them he was conservative. He was, however, again banished from France, and did not return until the general amnesty of 1879. In Switzerland he began his great 'Nouvelle geographie universelle,' the nineteen volumes of which were completed in 1894. He left at the time of his death an unpublished work in four volumes treating history as influenced by geographical conditions. During the later years of his life he was a professor in the Université libre of Brussels. We reproduce here a portrait from *La Nature*. Reclus is said to have been a man of the most intense human sympathy, always ready to sacrifice himself for his communistic and anarchistic convictions. Yet he found time to accomplish a vast



Elisée Reclus.

amount of work, noteworthy for its attractive style as well as for its scientific accuracy.

SCIENTIFIC ITEMS.

WE regret to record the death of Professor De Witt Bristol Brace, head of the Department of Physics of the University of Nebraska, and of Baron Ferdinand von Richthofen, professor of geography in the University of Berlin.

DR. W J MCGEE, U. S. Commissioner of the International Archeological and Ethnological Commission, lately chief of the department of anthropology and ethnology of the St. Louis Exposition and ethnologist in charge of the Bureau of American Ethnology, has been appointed managing director of the St. Louis Public Museum.—H. Foster Bain, Ph.D. (Chicago), geologist of the U. S. Geological Survey and formerly assistant state geologist of Iowa, has been appointed state geologist of Illinois.—Dr. Melvill Dewey has resigned the directorship of the New York State Library and of the Home Education Department. It is expected that a statement may be made later in regard to the causes of Dr. Dewey's resignation and the future of the library school which he has conducted.

MR. JOHN D. ROCKEFELLER has now paid to the General Education Board the $10,000,000 in accordance with the announcement made last June. The income, it will be remembered, will be distributed to promote a comprehensive system of higher education in the United States, and it is assumed, though perhaps not correctly, that the larger part will be given to the denominational colleges. The secretary of the board is the Rev. Dr. Wallace Butterick, 54 William Street, New York City.—By the will of the late General Isaac J. Wistar, the Wistar Institute of Anatomy and Biology of the University of Pennsylvania, founded by him, will receive the residue of his estate, thought to amount to about $400,000.

MESSRS. HOUGHTON, MIFFLIN & CO. announce that they will publish in eight volumes the Proceedings of the International Congress of Arts and Science, held at St. Louis, in September, 1904. The volumes, ranging from 500 to 800 pages, have the following titles: 1. 'Philosophy and Mathematics'; 2. 'Politics, Law and Religion'; 3. 'Language, Literature and Art'; 4. 'Inorganic Science'; 5. 'Biology and Psychology'; 6. 'Medicine and Technology'; 7. 'Social Sciences'; 8. 'Education and Religion.'